ON FLUORIDE TABLETS

A RETROSPECTIVE STUDY OF INTAKE PATTERN AND THE PREERUPTIVE EFFECT ON OCCURRENCE OF CARIES, RESTORATIONS AND FLUOROSIS IN TEETH

JAN WIDENHEIM

MALMÖ 1985

Diss
Lund
1985

Digitized by the Internet Archive
in 2026

https://archive.org/details/IA41546224_0029

ON FLUORIDE TABLETS

A RETROSPECTIVE STUDY OF INTAKE PATTERN AND THE PREERUPTIVE EFFECT ON OCCURRENCE OF CARIES, RESTORATIONS AND FLUOROSIS IN TEETH

AKADEMISK AVHANDLING

som för avläggande av odontologie doktorsexamen vid Odontologiska Fakulteten, Lunds Universitet, offentligen kommer att försvaras i aulan, Tandläkarhögskolan, Malmö, fredagen den 24 maj 1985, kl. 9.00

av

JAN WIDENHEIM
Leg. tandläkare

Organization
LUND UNIVERSITY
Department of Pedodontics
School of Dentistry
University of Lund
S-214 21 Malmö, Sweden

Document name
DOCTORAL DISSERTATION
Date of issue
April, 1985
CODEN: LUODD5/ODPE-1001/1-88/1985

Author(s)
Jan Widenheim

Sponsoring organization

Title and subtitle

ON FLUORIDE TABLETS - A retrospective study of intake pattern and the preeruptive effect on occurrence of caries, restorations and fluorosis in teeth

Abstract

Sixtynine % of children born in 1967 had taken NaF tablets at some time during the period ½-7 years of age, and 13 % had consumed such regularly for minimum 5½ years. The corresponding figures for children born in 1972 were 51 and 12 %. The diminished use probably reflected the ongoing debate about fluoride consumption. It was concluded, that self-administration of NaF tablets is questionable as a large-scale method.

Caries development in the children born in 1967, who had consumed NaF tablets daily for minimum 5 years during the period ½-6 years of age (F^+-group), was followed from 12 to 17 years of age. This group was compared with class-mates who had never consumed such tablets (F^--group). For consideration of background factors, i. e. confounders, a model for analysis was elaborated. The salivary counts of Streptococcus mutans and lactobacilli turned out to be the strongest confounders, and were further used. The crude difference (1.1 proximal Decayed and Filled Surfaces) in caries prevalence in posterior teeth between the F^--group (2.3 DFS) and the F^+-group (1.2 DFS) at the age of 12 was statistically significant at the 5 % level, and corresponded to a reduction of 48 %. Correction decreased this to 34 %. At the age of 17, the analogous reductions were 21 and 15 %, and there was a crude mean of 7.1 DFS in the controls vs. 5.6 DFS in the tablet group. The difference was statistically not significant.

Of the maxillary incisors, 29 and 15 % respectively in the F^+- and F^--groups had enamel fluorosis according to the system of Dean, and 38 and 16 % diagnosed with the Thylstrup & Fejerskov system. In no case was the fluorosis cosmetically disturbing. The relationship between the two scales was studied, and corrections were proposed for epidemiologic surveys.

The prevalence of restorations was lower in the tablet consumers than in the non-consumers, both in the primary teeth at the age of 8 and in the permanent teeth, according to records from the Public Dental Service clinics. This implies a favorable cost-effectiveness outcome, which was estimated concerning permanent teeth.

Key words
Dental caries; enamel fluorosis; fluoride tablets; lactobacilli; microbiology, oral; parental attitudes; preschoolchildren; prevention; Streptococcus mutans

Classification system and/or index terms (if any)

Supplementary bibliographical information

Language
English

ISSN and key title

ISBN

Recipient's notes

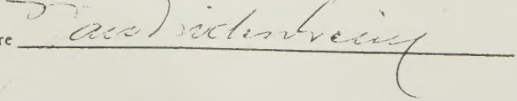
Number of pages
88

Price

Security classification

Distribution by (name and address)

I, the undersigned, being the copyright owner of the abstract of the above-mentioned dissertation, hereby grant to all reference sources permission to publish and disseminate the abstract of the above-mentioned dissertation.

Signature 

Date April 25 1985

DOKUMENTDATABLAD enl SIS 61 41 21

ON FLUORIDE TABLETS

A RETROSPECTIVE STUDY OF INTAKE PATTERN AND THE PREERUPTIVE EFFECT ON OCCURRENCE OF CARIES, RESTORATIONS AND FLUOROSIS IN TEETH

JAN WIDENHEIM

Departments of Pedodontics and Cariology,
School of Dentistry, University of Lund, Malmö
and Department of Mathematical Statistics,
University of Lund, Lund, Sweden

MALMÖ 1985

The English has been checked by Patrick Hort, M.A.

This investigation was supported by Grants for Promotion of Medical Research placed at the disposal of the Faculty of Odontology, University of Lund, Sweden, and by Grants from Malmöhus County Council, Lund, Sweden.

Author's address:
Dr. Jan Widenheim
Department of Preventive Dentistry
Malmöhus County Council
Gasverksgatan 17
S-252 25 Helsingborg
Sweden

Printed in Sweden by Infotryck ab, Malmö 1985

CONTENTS

Preface	4
Introduction	5
Aims of the study	10
Materials and methods	11
Results	15
Discussion	21
Summary	27
References	30
Paper 1	37
Paper 2	45
Paper 3	55
Paper 4	71

PREFACE

The present thesis is based on the following papers:

Paper 1 WIDENHEIM J. A time-related study of intake pattern of fluoride tablets among Swedish preschoolchildren and parental attitudes. Community Dent Oral Epidemiol 1982; 10: 296-300.

Paper 2 WIDENHEIM J, LINDGREN G, GRANATH L, BIRKHED D. Model for the study of the preeruptive effect on NaF tablets on caries in permanent teeth. Community Dent Oral Epidemiol 1985; 13: 86-92.

Paper 3 WIDENHEIM J, BIRKHED D, GRANATH L, LINDGREN G. Preeruptive effect of NaF tablets on caries in children from 12 to 17 yr of age. Community Dent Oral Epidemiol 1985; accepted for publication.

Paper 4 GRANATH L, WIDENHEIM J, BIRKHED D. Diagnosis of mild enamel fluorosis in permanent maxillary incisors using two scoring systems. Community Dent Oral Epidemiol 1985; accepted for publication.

Original data on restorative care in the primary and permanent dentitions, and a cost-effectiveness analysis are also included in the thesis.

INTRODUCTION

Fluorine is considered to be essential for animal life, with significance for the formation and function of bodily tissues, particularly mineralized tissues (1). Accordingly, in 1973 the World Health Organization designated fluorine as an essential nutritive substance (2). Much interest has been devoted to the mediating role of fluorine (in the following referred to as fluoride, the binary compound of fluorine) in the mineralization process of skeletal and dental tissues. Specifying the fluoride needed for bone formation and maintenance has proved difficult on account of the substance's complicated incorporation and release systems. However, fluoride requirements with regard to effects in teeth have been studied extensively. The optimal daily supply of fluoride has been empirically estimated from the intake with food and water in areas with varying concentrations of fluoride in the drinking water (3-5). A concentration of about 1 ppm has been found to have a maximum cariostatic effect without aesthetic disadvantages (6,7). In fluoride-deficient areas, with respect to climatic conditions, it is recommended that the waterborne fluoride is supplemented with fluoride drops or tablets. Fluoride as an additive to salt, flour and milk has been tested but not implemented on a large scale.

In Scandinavia, fluoride tablets are recommended for children from the first year of life up to the age of about 12 years. Such tablets have been used in Sweden since the early '50s and recommendations and dosage schedules were drawn up in 1959, 1971 and 1977 shown in Tables 1, 2 and 3 (8-10). In the current recommendations, issued by the National Swedish Board of Health and Welfare in 1977 (10), administration of sodium fluoride (NaF) tablets is principally recommended for a preeruptive effect on the mineralization of the permanent teeth, from ½ to 6 years of age. At low ages, the tablets should be dissolved in water; later, chewing or sucking is recommended for a posteruptive topical effect on, mainly, primary teeth. The directions also state that the tablets can be used throughout the preeruptive period of permanent teeth, third molars excluded, i.e. up to the age of 12. Advice on tablets is given to parents at Child Health Centers and Public Dental Service clinics. However,

Table 1. Recommended daily intake of NaF tablets, Sweden 1959.

	Ppm F^- in drinking water		
	0 - 0.25	0.25 - 0.50	0.50 - 0.75
Pregnant and breast-feeding women	4	3	2
0 - 1 year (after weaning)	1	-	-
1 - 6 years	2	1	-
7 - 12 years	3	2	1
> 12 years	4	3	2

Table 2. Recommended daily intake of NaF tablets, Sweden 1971.

	Ppm F^- in drinking water		
Age in years	0 - 0.25	0.25 - 0.50	> 0.50
½ - 1½	1	-	-
1½ - 6(7)	2	1	-

Table 3. Recommended daily intake of NaF tablets, Sweden 1977.

	Ppm F^- in drinking water		
Age in years	< 0.25	0.25 - 0.75	> 0.75
½ - 1½	1	-	-
1½ - 6(12)	2	1	-

earlier Swedish reports on intake frequency, obtained by interview (11,12), questionnaire (13,14) or utilized prescriptions (15), showed a considerable variation. The different results might have to do with the ongoing public debate on the utility of fluoride.

The recommendations for NaF tablets were originally based on the concept that fluoride can exert an influence on teeth in various ways. Firstly, it may increase the enamel's resistance to acid dissolution by being incorporated during formation of the teeth; secondly, the enamel surface is enriched in fluoride preeruptively during the late phase of maturation and also posteruptively; and thirdly, fluoride enhances remineralization of incipient caries lesions. Other conceivable factors are an interference with microorganisms and a lowered enamel surface energy, with less plaque adhesion. These cariostatic mechanisms have been comprehensively surveyed by Brown and König (16).

The different mechanisms of fluoride in cariostasis are difficult to rank by clinical significance. In recent years the various modes of action and their effects have been reassessed; the importance of the preeruptive effect, which presupposes that the main factor is fluoride incorporation in the enamel, with reduced solubility as a consequence, has been questioned (17,18). The presence of fluoride in the oral environment during de- and remineralization has been suggested as the determining factor, with a negligible cariostatic effect from the preeruptive build-up of fluoride in enamel.

A great many investigations on the effect of fluoride tablets on caries have been undertaken all over the world since the '40s. The effects on primary and permanent teeth have been thoroughly reviewed, with summaries by, for instance, Poulsen & Möller (19), Driscoll (20) and Binder et al. (21). As study designs and prerequisites have differed greatly, it is hardly surprising that the same applies to the reported reductions of caries. However, reductions of about 40-80 % in both the primary and the permanent dentition have been reported when supplementation commenced before 2 years of age (22). In the case of permanent teeth, the reduction seemed to be somewhat higher when tablet consumption started in the first year of life, Table 1 in Paper 3 (13,23-29). This could be interpreted as a result of a preeruptive effect of the tablets. However, in most of these trials the study of caries development was either discontinued

when the children still were at an early age and few permanent teeth had erupted, or the NaF tablet program was continued to a higher age, with a concomitant topical effect of the tablets. In no case has the preeruptive effect of fluoride tablets been isolated and the subsequent prevalence of caries in permanent teeth followed up during the caries-active period in youth.

These circumstances are understandable from a practical viewpoint. When studying the effect of a preventive measure, one should compare the effect in individuals or groups whose characteristics in other respects are as similar as possible. The randomized clinical trial is the ideal model if a sufficient number of subjects are available. It poses great difficulties, however, when one is investigating the effect of fluoride tablets. Parental attitudes towards participation would obstruct the planning of such a study, and the need for long-term cooperation can result in an unacceptable number of dropouts, preferentially among less motivated families. The latter has been shown in several studies (30). Similar objections apply to retrospective studies, as children who have consumed the tablets can be assumed to have better dietary and oral hygiene habits. Consequently there is reason to suppose that reported caries reductions after preeruptive supply of fluoride tablets are overestimates. In conclusion, these shortcomings emphasize the need to control background factors as thoroughly as possible, a need that applies in general to analytical epidemiological studies of preventive methods (31-35). It is made particularly essential by the multifactorial nature of dental caries.

When studying the caries-reducing effect of a preventive measure, it is appropriate also to estimate the gain, if any, for community dentistry (36,37). It is therefore of interest to elucidate the long-term restorative care and its costs after preeruptive intake of NaF tablets. This has seldom, if ever, been done in earlier studies.

The only known biological disadvantage of a controlled systemic supply of fluoride, estimated optimal with respect to caries prevention, is the risk of dental fluorosis. Several studies of the effects of fluoride intake from early infancy have reported enamel fluorosis in permanent teeth (13,28,29,38-40). In 1979 a new, more sensitive scoring system was introduced by Thylstrup & Fejerskov (41). In the further evaluation of the preeruptive effect of fluoride tablets on

caries, it should therefore be of interest to complement the studies with simultaneous diagnosis of fluorosis, scored according to the new system as well as to the classical system of Dean (42). An analysis of the relationship between the two scales would facilitate comparisons of earlier and future results.

Starting from the background outlined above, the aims of this study were as follows.

AIMS OF THE STUDY

The aims of this study were

* to investigate the intake pattern of NaF tablets among Swedish preschool children, and parental attitudes

* to elaborate a model for assessing the effect of a preventive measure, here NaF tablets, on caries with due consideration of confounding factors

* to investigate, with the elaborated model, the long-term effect of preeruptive supply of NaF tablets on caries in permanent teeth

* to assess any benefits, for community dentistry, of administration of NaF tablets during preschool age on restorative care in youth; in addition to study the prevalence of restorations in the primary dentition in the same subjects

* to investigate the occurrence and severity of enamel fluorosis in permanent teeth as a result of systemic administration of NaF tablets during tooth formation, using two scoring systems

MATERIAL AND METHODS

This series of studies was carried out in Lund, a Swedish university town with about 80,000 inhabitants. The municipal drinking water contained 0.2 ppm F^-, with only small variations during the study.

In 1975 and 1980, NaF tablet consumption between 0-7 years of age was surveyed in all 8-year-olds by questionnaires to parents. In both years the age group comprised about 700 children. The proportion of returned questionnaires was 82 % and 93 %, respectively. It was found that 373 children in 1975 and 474 in 1980 had been born in Lund and had resided there since then. They constituted the population studied. All details of the inquiry are presented in Paper 1. The parent was also asked about the child's use of toothpaste and, in 1980, mode of tablet consumption, reasons for not giving tablets to the child, and the age at which the child started to use fluoride toothpaste. Moreover, from both materials samples were chosen in order to study the duration of tablet consumption in relation to parental education.

From the 1975 material, the children who had consumed tablets daily in accordance with the recommendations (8,9) for minimum 5 years during the period ½-6 years of age, were selected for further study of the preeruptive effect of the tablets on permanent teeth. They comprised 50 subjects. None of them had used tablets after the age of 7. These children are referred to as the F^+-group. All the 76 children in same school classes who had never consumed NaF tablets, were registered as controls, here designated the F^--group. All children participated from the age of 6 in the school-based preventive program of Malmöhus County, designed according to recommendations from the National Swedish Board of Health and Welfare (43). Besides advice on diet and oral hygiene and hygiene instructions, the program included mouthrinses with 0.025 % NaF solution from the age of 6 and from the age of 7 0.2 % solution. Permanent teeth were treated with a fluoride varnish (Duraphat®) approximately once a year. In addition, since preschool age the children had used fluoride toothpaste daily at home. This is recommended from the age of 4 (10).

The subjects were called for the first examination in 1979, when they were about 12 years old, and after that in 1980, 1981 and 1984, at the ages of about 13, 14 and 17 years. At 17 the F^+-group consisted of 47 children and the F^--group of 69, the dropout during the study being due to moving from the district (6 children) and non-attendance (4 children).

Before assessing of the caries-reducing effect of NaF tablets, a model was elaborated for taking background factors into account. The methodology is described in detail in Paper 2. Briefly, for this purpose individual information about dietary habits, oral hygiene (represented by gingivitis and plaque) and microbial analysis of saliva (estimated number of Streptococcus mutans and lactobacilli per ml saliva) (44) was recorded in the F^-- and F^+-groups in 1979 and 1980. The subjects were dichotomized with respect to each of the variables, into "less favorable" and "favorable" fractions. The statistical analysis included correlations between the variables (fluoride excluded) and caries (examined on posterior bitewing radiographs from the corresponding years), the discriminating effect, and also the interaction of the variables (fluoride included).

The numbers of carious (D) and restored (F) mesial surfaces (S) among permanent first molars were used to express the prevalence of caries in 1979. Moreover, in 1979 and 1980, carious and filled surfaces were recorded on maximum 24 posterior proximal surfaces, and the caries incidence 1979-80 was calculated in terms of the individual DFS value in per cent of surfaces at risk during the period.

Analysis of the interaction effect on caries of two factors at a time was performed in four-fold contingency tables, and a model, presented in Paper 2, was constructed for the serial-step analysis of mean differences between the F^-- and F^+-groups, permitting simultaneous correction for two or more confounders. For each subgroup, formed by one or two confounders, the difference between the F^-- and the F^+-children was calculated. Crude and weighted mean differences constituted the basis for a discussion of the effect of fluoride tablets. It was decided that S. mutans and lactobacilli should be used as confounding factors in the subsequent study.

For a conclusive evaluation of the effect of fluoride tablets on caries, the children were called for additional radiographic and mic-

robial examination at the age of 14 (1981). The incidence of caries was determined separately for the periods 1979-80 and 1980-81, as the DFS increment during each year. The total prevalence in 1981 was calculated by adding the incidences in these years to the prevalence in 1979. In the correction procedure, the salivary counts of S. mutans and lactobacilli in 1979, and the mean counts of these bacteria in 1979-80 and 1980-81, were used in order to match the corresponding caries values with as time-related microbial data as possible. The caries differences between the F^-- and F^+-groups were estimated before and after correction for confounding, according to the elaborated model. This analysis is described in Paper 3. The final examination of the subjects was accomplished in 1984, in the year of their 17th birthday, and is described in the same paper. Bitewing radiographs were taken and analyzed for caries as previously for comparison between the groups.

As a complement, not presented in the papers underlying this thesis, the frequency of restorations (fs) in primary canines and molars in the population under study was obtained from records of the Public Dental Service for 1975, when the subjects were 8 years old. Among the participants in the study of permanent teeth up to the age of 17 (116 subjects), data were found on 114 children, 68 in the F^--group and 46 in the F^+-group. Extracted teeth were considered to have been restored or indicated for restoration, canines counted as one and molars as two restored surfaces. For 40 children in the F^--group and 24 in the F^+-group, posterior radiographs were available for detailed analysis.

To evaluate the profitability of NaF tablet consumption as to restorations performed in the permanent teeth the regular records of the subjects, received from the clinics, were examined early in 1984. This has not been reported on in the papers underlying this thesis. All restorations were registered for each child, and a cost-effectiveness ratio (36,37) was calculated as follows:

$$\text{Cost-effectiveness ratio (CER)} = \frac{\text{average cost of procedure/person/yr}}{\text{mean FS saved/person/yr}}$$

The time spent on informing parents regarding NaF tablets at the Child Welfare Centre was estimated. Neither parental time off from work nor travelling time were included because the visit usually was coordinated with a medical and dental examination of the child at the Centre. Expenditure on NaF tablets by the parents was included in the costs. The cost of the tablet program as well as the mean FS saved were spread over the total period, from ½ to 16½ years of age. The 1985 price level was used.

Diagnosis of enamel fluorosis of buccal surfaces was performed in maxillary incisors when the children were 13 years of age. This study is reported in Paper 4. The material comprised 69 subjects in the F^--group and 49 in the F^+-group, with 272 and 193 teeth available for examination respectively. Each incisor was first diagnosed according to the system of Dean (42), thereafter to that of Thylstrup & Fejerskov (41). The children were subgrouped with respect to the tooth with the most advanced degree of fluorosis, and the F^-- and F^+-groups were compared. The relation between the steps of the scales were finally analysed.

At the statistical analyses, differences at the 5 % level were considered significant.

RESULTS

From Table 1 in Paper 1 it appeared that 69 % of the children born in 1967 and 51 % of those born in 1972 had taken NaF tablets for some time, regularly or sporadically, during the period ½ - 7 years of age. Tablets had been consumed for 5½ years by 13 % and 12 %, respectively, and for 4½ years by about 18 % in both groups. The decrease in the intake with time, evident from the inquiries in 1980 compared to those in 1975, seemed to be more pronounced in sporadic and short-time consumers and in children of parents with a higher education (Table 3 in Paper 1); also 31 % of the parents in the 1980 population believed that fluoride can be harmful, Table 2 in Paper 1. About 90 % of the children, studied in 1980, had chewed or sucked the tablets, and a similar proportion of both populations used fluoride-containing toothpaste at the time of investigation. About 45 % of the children born in 1972 used the toothpaste before the age of 4.

From Paper 2, describing the model for analysis, it could be concluded that the chosen background factors correlated weakly with caries in the subjects selected for subsequent investigations. The discrimination ability was, however, good and acceptable interaction was found for S. mutans, lactobacilli and oral hygiene (measured as the number of bleeding units). S. mutans turned out to be the strongest confounder, lactobacilli ranked second and oral hygiene third, in both 1979 and 1980. As the discriminative power of diet and plaque was low, these variables were omitted from the rest of the study.

Furthermore, the results showed that there was less caries in the F^+- than in the F^--groups, measured as prevalence on the mesial surface of first molars in 1979 and as increment on proximal surfaces of posterior teeth from 1979 to 1980, with a reduction of about 40 % on both occasions (Tables 2 and 3 in Paper 2). However, after correction for the confounding effects of S. mutans and lactobacilli, these differences were reduced by 10 percentage units in 1979 and 18 in 1980, Table 7 in Paper 2.

At the 1981 examination (Paper 3), when the subjects were 14 years old, the statistically significant inter-group difference in caries prevalence of posterior teeth was 1.5 proximal DFS, correspon-

ding to a 34 % reduction (Table 2 in Paper 3). Correction lowered the reduction to 24 %, corresponding to a caries difference of about 1 DFS. This weighted mean difference was statistically not significant. The analysis of caries progression from 1979 to 1981 showed that the main difference between the groups existed in 1979. Between 1980 and 1981 there was practically no further reduction - the caries increment was the same in the two groups. This resulted in a diminishing caries reduction from 1979 to 1981, in crude values from 48 to 34 % and in corrected values from 35 to 24 %. Exclusion of first molars indicated that the caries difference between the F^-- and F^+-groups predominantly concerned these teeth. The percentage crude and corrected reductions, however, were still higher after exclusion of first molars, both in 1979 and for the incidence period from 1979 to 1980. In 1981 the prevalence reductions were almost the same, whether first molars were excluded or not.

The final examination of the subjects, at the age of 17 (Paper 3), supported the diminishing caries reduction described above. The caries data for the entire 5-year period, 1979-84, are shown in Table 4. Between 1981 and 1984 the caries increment (2.6 DFS) was practically the same in the F^-- and F^+-groups, which resulted in a diminished crude reduction of 22 % in 1984. As there was a negligible caries difference between the groups in the 1981-84 period and no data on background factors were available for the time in question, the corrected reduction was calculated using the sum of the weighted mean differences in 1979, 1979-80 and 1980-81. Thus, the corrected reduction of prevalence between NaF tablet consumers and non-consumers at the age of 17 came to 15 %.

At the age of 17, there was one subject without any restorations in the F^--group compared to 12 in the F^+-group. No cuspid had been restored because of caries, nor free smooth surfaces of any tooth. The mean values of restored surfaces, distributed among different teeth, are shown in Table 5. The F^--group had a mean of 7.3 FS compared to 3.8 in the F^+-group. The difference, 3.5 FS, represents a reduction of 47 % ($p < 0.01$) and mostly comes from 1.6 Class I and 0.9 Class II cavity restorations. The mean FS on posterior proximal surfaces was 1.5 in the F^-- and 0.6 in the F^+-group. The difference, 0.9 FS, corresponds to a reduction of 60 %, which turned out to be

Table 4. Differences in caries between fluoride tablet consumers (F^+), minimum 5 yr from ½ to 6 yr of age, and non-consumers (F^-); $\bar{x}$ = means of DF proximal surfaces (from mesial surface of permanent second molars to distal surface of first premolars); $d_{\bar{x}}$ and $SE_{d_{\bar{x}}}$ = differences of crude values and standard errors of differences; d_w and SE_{d_w} = weighted mean differences after correction for S. mutans and lactobacilli and standard errors of weighted mean differences; 1984 values = sum of prevalence in 1979 and incidences during 1979-80, 1980-81 and 1981-84; n in F^--group = 69, n in F^+-group = 49 in 1979-81 and 47 in 1981-84; p = level of significance in one-tailed tests.

	F^-	F^+	$d_{\bar{x}}$	$SE_{d_{\bar{x}}}$	d_w	SE_{d_w}	Reduction in % crude	Reduction in % corrected
1979 (12 yr)	2.36	1.22	1.14	0.39	0.82	0.41	48.3	34.7
1979-80 (12-13 yr)	1.25	0.88	0.37	0.43	0.20	0.44	29.6	16.0
1980-81 (13-14 yr)	0.87	0.84	0.03	0.30	0.04	0.27	3.4	4.6
1981-84 (14-17 yr)	2.65	2.63	0.02				0.8	
1984 (17 yr)	7.13	5.57	1.56		1.06		21.9	14.9

$p > 0.05$

Table 5. Mean values ($\bar{x}$) and standard errors (SE) of restored surfaces from records in NaF tablet consumers, minimum 5 years from ½ to 6 years of age (F^+; n = 47), and non-consumers (F^-; n = 69) at the age of 17 years; P = premolars, M_1 = 1st molars, M_2 = 2nd molars; correction for confounding factors not performed

Group		Occlusal (Class I)			Occlusal (Class II)		Proximal (Class II)		Proximal (Class III)	Total
		P	M_1	M_2	$P+M_2$	M_1	$P+M_2$	M_1	Incisors	
F^-	$\bar{x}$	0.20	2.42	1.74	0.38	0.90	0.41	1.09	0.13	7.26
	SE	0.06	0.18	0.19	0.14	0.16	0.14	0.21	0.07	0.63
F^+	$\bar{x}$	0.09	1.55	1.11	0.19	0.32	0.21	0.36	0	3.83
	SE	0.05	0.22	0.22	0.10	0.12	0.11	0.14	0	0.63
Diff.		0.11	0.87	0.63	0.19	0.58	0.20	0.73	0.13	3.43
"	(%)	55.0	35.9	36.2	60.2	64.4	48.9	67.0	100	47.2
p value		NS	<0.01	<0.01	NS	<0.01	NS	<0.01	NS	<0.01

the highest percentage difference except for incisors. Excluding first molars, the means of all FS were 2.9 and 1.6 ($p < 0.05$), and the means of FS on posterior proximal surfaces 0.4 and 0.2 ($p > 0.05$), in the F^-- and F^+-groups respectively (Table 5), the differences corresponding to reductions of 45 and 50 %.

At the cost-effectiveness analysis it was estimated that the information about and prescription of NaF tablets took 5 min/child/yr for 5 years, i.e. totally 25 min. The cost for staff, calculated on an average loss of revenues from the regular work of a dentist, dental hygienist or assistant, was estimated to 200 Swedish crowns (SEK)/hr. Expenditure on NaF tablets was calculated to 32 SEK/yr for 5 years, i.e. totally 160 SEK. Thus, the cost-effectiveness ratio was as follows:

$$CER = \frac{\frac{25}{60} \times 200 + 160}{3.43} = \frac{71 \text{ SEK}}{1 \text{ restored surface}}$$

The cost of a restored surface (1985) was approximately 148 SEK, calculated on the price range of Swedish Dental Insurance System, to which was added 38 % of the cost for higher expenses of practice in the Public Dental Service (37). This gave a cost-value of about 1:2.

The FS fraction of proximal DFS in posterior teeth was 21 % (1.5 out of 7.1) in the F^--group and 11 % (0.6 out of 5.6) in the F^+-group, Table 5.

The mean number of restored surfaces in the primary teeth (fs) at the age of 8 was 9.5 (SE = 0.81) in the F^--group and 3.6 (SE = 0.87) in the F^+-group. The difference, 5.9 fs, is statistically significant ($p < 0.001$) and corresponds to a non-corrected reduction of 62 %. For the limited number of subjects for whom radiographs were available, the fs fraction of proximal dfs was 68 % (4.5 out of 6.6) in the F^--group and 58 % (2.6 out of 4.5) in the F^+-group.

Diagnosis of enamel fluorosis according to Dean (42) resulted in a statistically non-significant difference of 14 % between the F^+- and F^--groups, with 29 and 15 % fluorosis respectively. However, the system of Thylstrup & Fejerskov (41) gave a statistically significant difference, with fluorosis in 35 and 16 % of the children in the F^+- and F^--groups, respectively. No tooth was scored higher than 2 according to Dean or 3 according to Thylstrup & Fejerskov. At all

levels there was a shift towards higher scores in the tablet group compared to the control group, irrespective of the scoring system. Comparison of the two scales revealed a logical relationship, accounted for in Table 5, Paper 4.

DISCUSSION

From this study it is clear that very few children consumed fluoride tablets as advised by dental staff at Child Health Centers and Public Dental Service clinics, according to recommendations from the National Swedish Board of Health and Welfare (8,9). There was even a tendency for the intake to decline in the latter half of the '70s. Neither is there any reason to suppose that the pattern of tablet consumption has changed in Sweden since then.

It was found that children who had consumed NaF tablets daily during the main period of tooth formation (approximately between ½ and 6 years of age) had a lower prevalence of registered caries at ages from 12 to 17 years compared to non-consuming class-mates. However, correction for confounding according to the present model considerably reduced the inter-group difference. There were also fewer restorations in the F^+- than in the F^--group in both dentitions. The cost-effectiveness ratio, determined for permanent teeth, was consistently favorable. It was also shown that NaF tablet consumers had a higher frequency of fluorosis than controls, but in no case was this aesthetically disturbing.

The analysis of caries prevalence (DFS) in posterior teeth (Table 2 in Paper 3) indicated that most of the difference between the F^-- and F^+-groups, registered at the age of 14, was already present at the age of 12 and localized to the permanent first molars. This is consistent, as the period after these teeth had erupted was considerably longer than for the remaining posterior teeth. The first molars could also have been topically influenced by the tablets up to the age of 7, all the more as the children had been encouraged to suck or chew the tablets. However, exclusion of first molars still left a substantial difference in percentage caries between the F^-- and F^+-groups, which indicates a real preeruptive effect.

An analysis of the reduction values over the entire period (Table 4) revealed that they diminished with advancing age. In 1979, the difference in DFS between tablet consumers and controls was 48 %, corresponding to rather more than 1 DF surface; five years later, in 1984, the figures were 22 % and 1.6 DFS, respectively. This is explained by an equal caries increment in the F^-- and F^+-groups

between the ages of 13 and 17 years, in spite of an increase of 4-5 DFS in both groups during the period. This follow-up of the development of caries in a longer perspective strengthens the opinion, that the systemic effect of fluoride tablets is overrated. However, one should also allow for the fact that this study was carried out in children with a basic preventive regime, including fluoride supply in toothpaste, mouthrinse solution and varnish (43). The superimposed effects of these topical applications may have masked part of the remaining effect of the tablets. In addition, the study population has a low caries prevalence.

As pointed out in the Introduction, confounding factors have seldom been considered when estimating the effects of preventive measures. In two examples, those of Granath et al. (33) and Tijmstra et al. (35), it was shown that a great deal of the difference in caries between NaF tablet consumers and non-consumers disappeared after correction for confounding. On the other hand, Andersson & Grahnén (13) reported that fathers of tablet-consuming children tended to belong to higher social groups than fathers in the control group; comparison of subjects from the same social group showed no difference in caries between tablet consumers and non-consumers.

Rothman (32) has defined the concept of confounding:

> "Confounding in the estimation of the effect of a given factor (in producing disease) may be defined as distortion in the estimate attributable to an extraneous variate. To produce confounding, an extraneous variate must be associated - in the subjects actually studied - with the factor (or exposure) under study, and independent of this association, also be a risk indicator for disease."

In the present study it was decided to choose confounding variables with, in the light of present knowledge, as close an association to caries as possible. The microbial factors used in the present study fulfil this criteria. S. mutans is considered to be a specific caries-inducing microorganism (45-48). Both S. mutans and lactobacilli can also, to a certain extent, be said to represent oral hygiene; furthermore, lactobacilli reflect sugar consumption (49). The

existence of relatively objective methods for the registration of these bacteria is an additional advantage (44).

The number of bacteria was greater in the F^-- than in the F^+-group in the present study, which confirms the relationship between tablet consumption and good dietary and oral hygiene habits.

For the correction of crude caries values for confounding it was the intention to use mean values of the variables in a model with a simplified structure. A multiple regression analysis, for instance, would have to contain non-linear terms, which is questionable, and might involve complicated mathematical operations with obscure results. However, the model used in the present study also has evident weaknesses, though the variables do primarily behave logically in discrimination and interaction analyses. Some observations can differ significantly from the rest and distort the mean value of the group. Further, the dichotomy of the variables calls for a fairly equal distribution of the subjects over subgroups, which might be a statistical shortcoming if the distribution of the population is skewed for the characteristic in question. With small numbers of observations in a group after dichotomy, interpretations should be made with great restraint.

The correction model worked satisfactorily in this study, and allowance for the confounding factors decreased the crude reductions. This is illustrated in Table 4. Between 12 and 13 years of age (1979-80) the caries difference between the F^-- and F^+-groups corresponded to a crude reduction of 30 %. Correction almost halved this (16 %). This considerable adjustment is probably a consequence of the up-to-date mean values of the confounding factors versus caries. The 1979 caries prevalence - the result of occurrences of caries since the time when the teeth erupted - was on the contrary corrected with confounding factors from the end of the period. As expected, the difference between the crude and the corrected reduction was lower in this case.

In the 1980-81 and 1981-84 periods (Table 4) the caries increment was the same for consumers and non-consumers, with no basis for correction. However, at the age of 17 there still was an inter-group difference, corrected for confounding, of 15 %, indicating a persistent preeruptive effect. In Paper 3 this was commented as

follows: "It may be that an even more effective confounding system, comprising more factors and therefore requiring a larger sample of subjects, would have further reduced the crude differences. There is no reason, however, to suppose that the differences would have been completely eliminated under such circumstances."

The relative importance of the various caries-reducing mechanisms of fluoride is under debate. There is general agreement about the significance of fluoride for the de- and remineralization processes, justifying the topical use of fluorides (50). The preeruptive effect, however, is questioned and considered hypothetical (17,18). Still, it has been suggested that improved cristallinity, ascribed to the presence of fluoride during mineralization, might do something for resistance to caries. Increased crystallite size and a favorable orientation of the crystallites may increase the resistance by reducing of the surface accessible for acids (51-53). These conditions might result in a lower progression rate of caries, but little has been done to investigate this.

The extent of the caries lesions in proximal surfaces has not been evaluated in the present study. However, the restored fraction of decayed and restored surfaces in posterior teeth was smaller in the F^+-group, in both permanent and primary dentitions. This may indicate that the lesions in the non-consumption group were somewhat more extensive than those in the consumers, indicating different progression rates. The outcome in permanent teeth was economically favorable, a factor that was taken into account when estimating the value of the NaF tablets in terms of community dentistry. While the basis for the calculation is debatable, the cost-effectiveness ratio of 1:2 was notably favorable, in the present study. To this should be added the gain from fewer restorations in the primary dentition of the F^+-group, as well as less risk of recurrent caries and periodontal disease relating to restorations. Moreover, the difference in restorations between the F^-- and F^+-groups has not been corrected for confounding, and is certainly overestimated. Another reservation is that a substantial part of the difference between the F^-- and F^+-groups was found in first molars. There is a possibility that these teeth also had benefitted from a topical effect of the NaF tablets. The children were in most cases advised to chew the tablets.

However, community effectiveness, i.e. prosperity under field conditions, was not so favorable for the NaF tablet regime. Only about half of the individuals in the original sample of about 400 children had taken tablets regularly for any length of time, and not more than about 15 % during the recommended period of 5-6 years, as accounted for in Paper 1. For a cost-benefit analysis, information is required on tablet intake and restorations in the total population.

The effect of a preventive measure should not be exclusively evaluated in the situation of a trial. Individual acceptance and performance must also be taken into consideration, which is certainly relevant for the administration of fluoride tablets. Community effectiveness, i.e. success under field conditions, did not favor the fluoride regime in this study. Very few children had the recommended intake of NaF tablets. This is partly explained by the ongoing debate in Sweden on environmental issues (14); many parents believed that swallowing fluoride could be dangerous. However, the fluoride debate has now largely ebbed. The main reason for the low compliance may have been the very long period of administration. Furthermore, many of the children in the 1980 population used fluoride toothpaste from an early age, despite a recommended start at the age of 4.

The frequency of enamel fluorosis, diagnosed according to the Dean system after NaF tablet intake in the present study, was lower than after consumption of drinking water containing an optimal fluoride concentration, according to an investigation performed in the city of Uppsala (54). This is noteworthy because it has been suggested that the immediate increase in the plasma concentration which occurs after tablet intake might imply a greater risk of disturbed enamel formation than that after consumption of optimal water (55,56).

The comparison of the scoring systems of Dean (42) and Thylstrup & Fejerskov (41) showed that the latter gave a higher difference between the F^+- and F^--groups. This is consistent with the higher sensitivity of the Thylstrup & Fejerskov scale. In order to avoid the appreciable risk of under- or overdiagnosing the very first signs of narrow white lines, it is recommended that possible white lines corresponding to perikymata should be scored zero when using the Thylstrup & Fejerskov scale in more extensive epidemiologic surveys. It is also suggested that Dean´s score 0.5 should be

changed to score 1, provided the enamel alterations are correctly diagnosed as fluorosis according to Nevitt et al. (57). These proposals are based on the experience that fluorosis increases step-wise with an increasing level of fluoride in drinking water (58), without a threshold dependence (41). After these modifications of the classifications, either scale can be used, and comparisons are reasonably facilitated. If more detailed information is required in experimental trials of limited size, use of the entire system of Thylstryp & Fejerskov is recommended.

To conclude, in the present study it was shown that administration of fluoride tablets during preschool age has a measurable preeruptive cariostatic effect on permanent teeth also in a society with a comprehensive preventive program. This effect could also be shown in terms of fewer restored surfaces and a favorable economic outcome. The frequency of enamel fluorosis in tablet consumers was higher than in non-consumers but in no case was the fluorosis cosmeticallly disturbing. This preventive measure should be of value even for the primary teeth. Whether administration of fluoride tablets can be used as a public health measure on a large scale, based on parental responsibility, is questionable and might largely be dependent on the knowledge and efforts of the dental staff.

SUMMARY

* In 1975 and 1980, questionnaires about consumption of sodium fluoride (NaF) tablets were sent to all parents of 8-year-olds in the city of Lund, Sweden. About 69 % of the children born in 1967 had taken tablets at some time during the period ½ - 7 years of age and 13 % had consumed tablets regularly for 5½ years. The corresponding figures for children born in 1972 were 51 and 12 %, respectively. The diminished use of NaF tablets during the period studied probably reflected the ongoing debate about systemically administered fluoride. Of the parents in the 1980 population, 31 % believed that fluoride supplementation can be harmful.

* A model for the study of effects of a preventive measure - here the preeruptive effect of NaF tablets - was elaborated. An analysis of background factors identified Streptococcus mutans and lactobacilli as the strongest confounders among the variables tested. They each discriminated well as a single factor and behaved logically in an analysis of interaction. They were used in the subsequent correction of caries values.

* The prevalence of caries was lower between 12 and 17 years of age in permanent teeth of children who had a regular consumption of NaF tablets during preschool age, compared to non-consuming class-mates. During the period the crude reduction diminished from 48 to 22 %. After correction in accordance with the model the corresponding reductions were 35 and 15 %. It was concluded that the remaining difference was due to a preeruptive cariostatic effect of NaF tablets. At the age of 17 the mean proximal DFS in posterior teeth was 5.6 and 7.1, respectively, among consumers and non-consumers.

* Subjects with NaF tablet supply had a lower total mean FS (3.8) than controls (7.3) at the age of 17. The difference is statistically significant and corresponds to a reduction of 47 %. In the primary dentition, calculated on cuspids and molars at the age of 8 years, the analogous reduction was 62 % (3.6 and 9.5 fs). The FS and the fs fraction of proximal DFS and dfs, respectively, in posterior teeth was less in tablet consumers than in non-consumers. This might indicate a lower rate of caries progression in the tablet group.

The difference in restoration frequency, although uncorrected, gives a favorable cost-effectiveness ratio.

* Of the maxillary incisors, 29 % and 15 % respectively in the tablet and the non-tablet group had enamel fluorosis, diagnosed with the scoring system of Dean; none exceeded score 2. The difference is not statistically significant. The system of Thylstrup & Fejerskov did give a statistically significant difference between the groups, with fluorosis in 35 % and 16 %, respectively, no tooth exceeding score 3.

To avoid over- or under-diagnosing in epidemiologic surveys, it is recommended that possible white lines corresponding to perikymata are scored zero when using the Thylstrup & Fejerskov scale. Moreover, score 0.5 according to Dean should be changed to score 1, on the assumption that fluorosis is diagnosed according to adopted agreements. This will facilitate comparisons of results obtained with the two scales.

* * *

In conclusion, the present study showed that fluoride tablet intake from early infancy and during the main period of tooth formation had a long-term cariostatic effect on permanent teeth, measurable even in a community with a comprehensive preventive program that included fluoride in toothpaste, mouthrinsings and varnish. No cosmetically

disturbing enamel fluorosis occurred. The caries-reducing effect on primary teeth was significant. The cost-effectiveness ratio of this preventive measure was favorable. However, self-administration of fluoride tablets appeared to be an unsatisfactory method of fluoride therapy on a large scale.

* * *

REFERENCES

1. BELL ME, LARGENT EJ, LUDWIG TG, MUHLER JC, STOOKEY CK. The supply of fluorine to man. In: Fluorides and human health. WHO monograph series No. 59, Geneva: WHO, 1970; 17-74.
2. A REPORT OF A WHO EXPERT COMMITTEE. Trace elements in human nutrition. WHO technical report series No. 532, Geneva: WHO, 1973.
3. McCLURE FJ. Ingestion of fluoride and dental caries. Quantitative relations based on food and water requirements of children 1 to 12 years old. Am J Dis Child 1943; 66: 362-9.
4. ADAIR SM, WEI SHY. Supplemental fluoride recommendations for infants based on dietary fluoride intake. Caries Res 1978; 12: 76-82.
5. NEWBRUN E. Dietary fluoride supplementation for the prevention of caries. Pediatrics 1978; 62: 733-7.
6. DEAN HT, ARNOLD F, ELVOVE E. Domestic water and dental caries. V. Additional studies of the relation of fluoride domestic waters to dental caries experience in 4,425 white children aged 12-14 years, of 13 cities in 4 states. Public Health Rep 1942; 157: 1155-79.
7. HODGE HC. The concentration of fluorides in drinking water to give the point of minimum caries with maximum safety. J Am Dent Assoc 1950; 40: 436-9.
8. KUNGL MEDICINALSTYRELSEN. Kungl Medicinalstyrelsens cirkulär till samtliga läkare och tandläkare angående individuellt utnyttjande av fluor för kariesprofylax. 1959:68.
9. SOCIALSTYRELSEN. Socialstyrelsens cirkulär om fluorprofylax till barn under 7 års ålder. 1971; No. 69.
10. SOCIALSTYRELSEN. Socialstyrelsens kungörelse om användning av fluorider i kariesprofylaktiskt syfte. SOSFS(M) 1977:26.
11. HOLM A-K. Oral health in a group of Swedish children. Community Dent Oral Epidemiol 1975; 3: 184-9.
12. HOLM A-K. Dental health in a group of Swedish 8-year-olds followed since the age of 3. Community Dent Oral Epidemiol 1978; 6: 71-7.

13. ANDERSSON R, GRAHNÉN H. Fluoride tablets in pre-school age - effect on primary and permanent teeth. Sven Tandlaek-Tidskr 1976; 69: 137-43.
14. FORSMAN B, JACOBSSON D. Faktorer som påverkar konsumtionen av fluortabletter. En undersökning bland 4-åringar i Växjö. Tandlaekartidningen 1977; 69: 1339-41.
15. MALMBERG E. Förskrivning av fria fluortabletter i Göteborgs kommun 1976. Tandlaekartidningen 1976; 68: 968.
16. BROWN WE, KÖNIG KG. Cariostatic mechanisms of fluorides. Caries Res 1977; 11: Suppl 1: 1-327.
17. FEJERSKOV O, THYLSTRUP A, LARSEN MJ. Rational use of fluorides in caries prevention. A concept based on possible cariostatic mechanism. Acta Odontol Scand 1981; 39: 241-9.
18. FEJERSKOV O. Fluoride and enamel. Summary of session and panel discussion. In: Cariology Today. Int Congr, Zürich, 1983. Basel: Karger, 1984; 362-74.
19. POULSEN S, MÖLLER IJ. Anvendelsen af fluortabletter i caries-profylaksen. Tandlaegebladet 1969; 73: 1103-20.
20. DRISCOLL WS. The use of fluoride tablets for the prevention of dental caries. In: FORRESTER DJ, SCHULZ EM, eds. International workshop on fluorides and dental caries reductions. Baltimore: University of Maryland, 1974; 25-93.
21. BINDER K, DRISCOLL WS, SCHÜTZMANNSKY G. Caries-preventive fluoride tablet programs. Caries Res 1978; 12: Suppl 1: 22-30.
22. MURRAY JJ, RUGG-GUNN AJ. Fluorides in caries prevention. 2nd ed. Bristol: Wright, 1982; 85-99.
23. HAMBERG L. Controlled trial of fluoride in vitamin drops for prevention of caries in children. Lancet 1971; 1: 441-2.
24. SCHÜTZMANNSKY G. Fluorine tablet application in pregnant females. Dtsch Stomatol 1971; 21: 122-9.
25. AASENDEN R, PEEBLES TC. Effects of fluoride supplementation from birth on human deciduous and permanent teeth. Arch Oral Biol 1974; 19: 321-6.
26. BINDER K. In: DAVIES GN. Cost and benefit of fluoride in the prevention of dental caries. WHO Offset Publication No. 9. Geneva: WHO, 1974; 21-65.

27. MARGOLIS FJ, REAMES HR, FRESHMAN E, MACAULEY JC, MEHAFFEY H: Fluoride - ten year prospective study of deciduous and permanent dentition. Am J Dis Child 1975; 129: 794-800.
28. THYLSTRUP A, FEJERSKOV O, BRUUN C, KANN J. Enamel changes and dental caries in 7-year-old children given fluoride tablets from shortly after birth. Caries Res 1979; 13: 265-76.
29. HOLM A-K, ANDERSSON R. Enamel mineralization disturbances in 12-year-old children with known early exposure to fluorides. Community Dent Oral Epidemiol 1982; 10: 335-9.
30. NEWBRUN E. Systemic fluorides - an overview. J Can Dent Assoc 1980; 46: 31-7.
31. MIETTINEN O. Confounding and effect-modification. Am J Epidemiol 1974; 100: 350-3.
32. ROTHMAN KJ. A pictorial representation of confounding in epidemiologic studies. J Chronic Dis 1975; 28: 101-8.
33. GRANATH L, ROOTZEN H, LILJEGREN E, HOLST K, KÖHLER L. Variation in caries prevalence related to combinations of dietary and oral hygiene habits and chewing fluoride tablets in 4-year-old children. Caries Res 1978; 12: 83-92.
34. GRANATH L-E, SCHRÖDER U. Explanatory model for the interaction of factors in the caries process. Acta Odontol Scand 1978; 36: 253-6.
35. TIJMSTRA T, BRINKMAN-ENGLES M, GROENEVELD A. Effect of socioeconomic factors on the observed caries reduction after fluoride tablet and fluoride toothpaste consumption. Community Dent Oral Epidemiol 1978; 6: 227-30.
36. HOROWITZ HS, HEIFETZ SB. Methods for assessing the cost-effectiveness of caries preventive agents and produres. Int Dent J 1979; 29: 106-117.
37. SOU (Statens offentliga utredningar). Lönar det sig att tillsätta fluor i dricksvattnet? Rapport till fluorberedningen. Socialdepartementet. Stockholm, 1980:13: 59-63.
38. AASENDEN R, PEEBLES TC. Effects of fluoride supplementation from birth on dental caries and fluorosis in teenaged children. Arch Oral Biol 1978; 23: 111-5.

39. AASENDEN R, PEEBLES TC. Effects of fluoride supplementation from birth on human deciduous and permanent teeth. Arch Oral Biol 1974; 19: 321-6.
40. POWELL JA, NORBERT LD, HARGREAVES JA. Fluorosis and dental caries in children receiving fluoride supplementation. J Dent Res 1983; 62: Spec Issue. AADR Abstr No. 304.
41. THYLSTRUP A, FEJERSKOV O. Clinical appearance of dental fluorosis in permanent teeth in relation to histologic changes. Community Dent Oral Epidemiol 1978; 6: 315-28.
42. DEAN HT. The investigation of physiological effects by the epidemiological method. In: MOULTON FR, ed. Fluorine and dental health. Washington, DC: American Association for the Advancement of Science, 1942; 23-31.
43. SOCIALSTYRELSEN. Tandhälsovårdsprogram för barn och ungdom. Ett ramförslag. Socialstyrelsen redovisar. Stockholm, 1978:3.
44. KLOCK B, KRASSE B. Microbial and salivary conditions in 9- to 12-year-old children. Scand J Dent Res 1977; 85: 56-63.
45. IKEDA T, SANDHAM HJ, BRADLEY EL, Jr. Changes in Streptococcus mutans and lactobacilli in plaque in relation to the initiation of dental caries in Negro children. Arch Oral Biol 1973; 18: 555-66.
46. LOESCHE WJ, ROWAN J, STRAFFON LH, LOOS PJ. Association of Streptococcus mutans with human dental decay. Infect Immun 1975; 11: 1252-60.
47. VAN HOUTE J. Bacterial specificity in the etiology of dental caries. Int Dent J 1980; 30: 305-26.
48. HAMADA S, SLADE HD. Biology, immunology and cariogenicity of Streptococcus mutans. Microbiol Rev 1980; 44: 331-84.
49. ELLEN RP. Microbiological assays for dental caries and periodontal disease susceptibility. Oral Sci Rev 1976; 8: 3-23.
50. CATE JM ten. The effect of fluoride on enamel de- and remineralization in vitro and in vivo. In: Cariology Today. Int Congr, Zürich, 1983. Basel: Karger, 1984; 231-6.
51. GRÖN P, SPINELLI M, TRAUTZ O, BRUDEVOLD F. The effect of carbonate on the solubility of hydroxapatite. Arch Oral Biol 1963; 8: 251-63.

52. YOUNG RA, ELLIOT JC. Atomic-scale basis for several properties of apatite. Arch Oral Biol 1966; 11: 699-707.
53. AMJAD Z, NANCHOLLAS GH. Effect of fluoride on the growth of hydroxyapatite and human dental enamel. Caries Res 1979; 13: 250-8.
54. SOU (Statens offentliga utredningar). Fluor i kariesförebyggande syfte. Betänkande av fluorberedningen. Socialdepartementet. Stockholm, 1981:32: 213-20.
55. MYERS HM. Plasma fluoride levels in dental fluorosis. In: MYERS HM, ed. Fluorides and dental fluorosis. Monogr in oral sci 7. Basel: Karger, 1978; 56-63.
56. ERICSSON Y, WEI SHY. Fluoride supply and effects in infants and young children. Pediatr Dent 1979; 1: 44-54.
57. NEVITT GA, FRANKEL JM, WITTER DM. Occurrence of non-fluoride opacities and non-fluoride hypoplasias of enamel of 588 children aged 9-14 years. J Am Dent Assoc 1963; 66: 65-9.
58. MYERS HM. Dose-response relationship between water fluoride levels and the category of questionable dental fluorosis. Community Dent Oral Epidemiol 1983; 11: 107-12.

Paper 1

A time-related study of intake pattern of fluoride tablets among Swedish preschoolchildren and parental attitudes

JAN WIDENHEIM

Department of Pedodontics, School of Dentistry, University of Lund, and Department of Dental Prevention, Malmöhus County Council, Lund, Sweden

Widenheim, J.: A time-related study of intake pattern of fluoride tablets among Swedish preschoolchildren and parental attitudes. Community Dent. Oral Epidemiol. 1982: 10: 296–300.

Abstract – The principal aim of this study was to investigate sodium fluoride tablet consumption and its variability over a particular period. Information was collected from questionnaires sent in 1975 and 1980 to all parents of children born in Lund, Sweden, in 1967 and 1972 and still resident in this city, where drinking water contains 0.2 parts/10^6 F. The results showed that 69% of the children born in 1967 (n=373) had taken tablets at some time during the period ½–7 years of age and that 13% had consumed tablets regularly for minimum 5½ years. The corresponding figures for children born in 1972 (n=474) were 51% and 12%, respectively. Sporadic consumers were responsible for the main difference (15%) between the two populations. A selection of parents from the 1975 and 1980 materials was made with respect to duration of consumption and level of parental education. The frequency of non-users had increased mostly among families with a higher parental education. For those parents who had not given their children tablets or had ceased to do so, the 1980 inquiry was enlarged with questions about reasons for this. The item marked most frequently (56%) implied that fluoride may be dangerous to swallow. Another 13% responded that they had not been recommended to give their children tablets. However, topical use of fluoride in toothpaste during preschool age and in mouthrinses from 6 years of age is, according to the present study, well accepted.

Key words: fluoride tablets; parental attitudes; preschoolchildren.

J. Widenheim, Tandhälsovården, Gasverksgatan 17, S. 252 25 Helsingborg, Sweden.

Accepted for publication 22 May 1982.

Since the latter part of the sixties a dental preventive program has been run at child health centers and in the Public Dental Service in Sweden. This includes a recommendation to give children sodium fluoride tablets for caries prevention according to directions by the National Swedish Board of Health and Welfare (1). In areas where drinking water has a fluoride concentration <0.75 parts/10^6, daily supplementation is recommended at least during preschool age. The measure is designed principally for the permanent teeth.

The frequency of fluoride tablet intake among children in Scandinavia has been investigated by several authors. In Sweden, ANDERSSON & GRAHNÉN (2) reported that 5% and HOLM (3) that 20% of children born in 1965–67 and 1967, respectively, had taken tablets throughout the preschool period. Furthermore, the former authors found that 23% of the children had received tablets for some time. An earlier study by HOLM (4) had indicated that about 70% of 5-year-olds born in 1967 had used tablets for varying periods. ANDERSSON & GRAHNÉN (2) used a questionnaire, while HOLM (3, 4) interviewed the parents to obtain information. On the basis of prescriptions utilized in 1976, compiled by MALMBERG (5), a report from the Ministry of Health (6) calculated that 6% of the children in Gothenburg, Sweden, aged ½–6, had received tablets through-

Read in abbreviated form at the 63rd Annual Meeting of the Scandinavian Division of I.A.D.R. in Esbo, Finland, August 15–17, 1980.

0301-5661/82/060296-05 $02.50/0 © 1982 Munksgaard, Copenhagen

out the preschool period, while 38% had not used tablets at all. The 1976 supply in Norway, also estimated from collected prescriptions, covered as much as 50% of children 0–6 years of age (7). From a Danish study by THYLSTRUP *et al.* (8), based on offered prescriptions, it seems that just a few percent of children born in 1969 had received tablets throughout preschool age.

Information on fluoride consumption abroad has been reviewed by NEWBRUN (9). Community programs in which tablets were distributed for use at home have generally been unsuccessful because of poor compliance. This conclusion was based on independent reports from several countries for the period 1960–76, including Australia, Canada, England, Germany and United States. The reported use of tablets over the recommended period varied from a few to 50%. In addition, lack of parental interest in Australia has been confirmed by MCENIERY & DAVIES (10).

Information on changes in the use of fluoride tablets in Scandinavia during a certain period has been presented in a few investigations. Comparing consumption at the age of 4, HOLM *et al.* (11) reported that this was significantly lower in 1967 than in 1971, when 5% and 26%, respectively, had had tablets for 3–4 years. In a study by FORSMAN & JACOBSON (12) the frequency of children taking tablets at the age of 4 was 70%, 29% and 80% in 1969, 1972 and 1976, respectively. The sale of fluoride tablets in Norway had increased markedly in the period 1971–76, according to LÖKKEN *et al.* (7). The sales figures indicated that less than 1% of children aged 0–12 used tablets before 1971 compared to 35–40% of those in 1976.

Two Swedish investigations have charted the reasons why parents do not give their children fluoride tablets. ANDERSSON & GRAHNÉN (2) reported that of the parents who had never given their children such tablets, 49% declared that this had not been recommended, and 39% that they did not wish to medicate their children. The most frequent reason for not using tablets, according to FORSMAN & JACOBSON (12), was a negative influence from acquaintances or the mass media.

In Sweden the systemic supply of fluoride was widely discussed in the seventies and this is supposed to have influenced public opinion and the readiness to use fluoride tablets. Furthermore, municipal water fluoridation was under consideration by an official committee in 1977–81 (13). This has intensified the controversy about fluorides among journalists and the public at large.

The aim of this investigation, much as a result of the variability of earlier data, was to study the pattern of fluoride tablet intake among Swedish children during preschool age in the late seventies. This was done on two occasions in order to evaluate possible changes over a 5-year period, in the course of which the benefit of systemic fluoride administration has been strongly questioned. Based on studies elucidating the relationship between awareness of the importance of preventive measures in children and socioeconomic factors (11, 14–17), the correlation of tablet intake with parental educational factors was examined to some extent. The study, performed by questionnaires, also covered the attitudes of parents who had not given their children tablets or had ceased to do so. Furthermore, the mode of consumption of fluoride tablets and the habitual use of fluoride toothpaste during childhood were investigated.

MATERIAL AND METHODS

In 1975 and 1980, questionnaires were sent to all parents of 7–8-year-olds resident in the city of Lund, Malmöhus County. The questions concerned the duration and regularity of fluoride tablet intake during ages ½–7 years. The use of fluoride toothpaste was also surveyed. In 1980, but not in 1975, the questionnaire included questions about the mode of tablet consumption, reasons for not giving these tablets to the child in accordance with recommendations, and the age at which the child started to use fluoride toothpaste.

The fluoride content of the drinking water in Lund was 0.2 parts/10^6. With very few exceptions the children participated from the age of 6 in the school-based mouthrinse program, with a 0.2% sodium fluoride solution once a week, according to reports from Malmöhus County Council.

The number of 7–8-year-old children in Lund was 704 in 1975 and 692 in 1980. The proportion of returned questionnaires for corresponding groups was 82% and 93%, respectively. Non-respondents have not been investigated. Of the children in the 1975 and 1980 materials, 373 and 474, respectively, had been born in Lund and constituted the populations studied.

For the study of the correlation between duration of tablet intake and educational factors, information on parental occupation (in most cases the father's) was obtained from public records. The parents were divided into two groups, i.e. those with or without a profession based on a solid theoretical university education. Three groups of children from each of the 1975 and 1980 populations were chosen with respect to duration of consumption: 1) children who had taken tablets regularly for 6 years, 2) children who had taken them regularly from early infancy up to 2 or 3 years of age, and 3) random

Table 1. Frequencies of 7-8-year-old children born in Lund, Sweden, with respect to duration of fluoride tablet intake

	Year of birth 1967 (n=373) %	1972 (n=474) %	Diff.
Tablet users (Sporadics included)	69.4	50.8	−18.6
Regular consumers accumulated, Minimum years			
6½	6.2	3.6	−2.6
5½	13.2	11.9	−1.3
4½	18.8	17.6	−1.3
3½	25.3	25.0	−0.3
2½	30.6	32.8	+2.1
1½	39.6	39.7	+0.1
½	50.7	46.6	−4.1

samples of about the same magnitude as 1) and 2) from the many children who had never taken tablets. The distributions according to education in the random samples were used to calculate the corresponding figures for non-users in the total populations. It was then possible to compare the 1975 and 1980 materials for frequencies of subjects with respect to duration of consumption and parental education.

RESULTS

Table 1 gives the frequencies of children taking fluoride tablets and the duration of intake between half a year and 7 years of age in the two populations. Of the children born in 1967, 69% had consumed tablets during the period, compared with 51% of those born in 1972. These figures include children who had taken tablets for a longer or shorter time as well as regularly or sporadically. The Table also gives the cumulative frequencies from 6½ years to half a year among the regular consumers. Sporadic consumers were responsible for the main difference, 15%, between the two populations. Most of the children started the intake at ½-1 years of age in both materials. Calculated on the period half a year to 7 years of age, the proportion of children who had taken tablets regularly for a minimum of 5½ years was 13% and 12%, respectively, in the two populations.

Table 2. Reasons for not giving the child fluoride tablets according to answers by parents of 7-8-year-old children born in Lund, Sweden, in 1972 (n=474), who had not given or had ceased to supply tablets; 262 respondent parents

	%
1. Was not recommended to give the child tablets	13.0
2. Forgot to buy the tablets	7.2
3. The child refused to take the tablets	12.6
4. Do not believe in tablets to prevent caries	11.1
5. Think that swallowing the tablets can be dangerous	56.1
	100

The mode of consumption in the 1980 sample was that 87% of the children had chewed the tablets, 1% had sucked, and 12% had swallowed the tablets undissolved.

For those parents who had not given their children fluoride tablets at all or had ceased to do so, the 1980 questionnaire listed five alternative reasons for this. Table 2 shows that 56% supposed that it might be dangerous to swallow fluoride tablets, 13% were not recommended to give the child tablets, and 11% did not believe in the method for caries prevention.

Regarding toothpaste, about 86% of the children in the 1975 material and about 91% in the 1980 material used a paste containing fluoride at the time of the investigation. About 45% of the children

Table 3. Frequencies of children in selected groups of 7-8-year-olds born in Lund, Sweden, in 1967 (n=373) and in 1972 (n=474), with respect to duration of regular tablet consumption and parental education; number of children in brackets

	Year of birth	Consumption in years 6 %	1½-2½ (from early infancy) %	0 %
Lower parental education	1967	3.5 (13)	3.0 (11)	18.0 (70)
	1972	3.0 (14)	4.2 (20)	23.2 (110)
Higher parental education	1967	3.5 (13)	3.0 (11)	11.8 (44)
	1972	4.9 (23)	3.8 (18)	25.9 (123)

born in 1972 used the paste before the age of 4, contrary to the recommendation in force.

Table 3 cross-tabulates selected children with respect to duration of consumption of tablets and level of parental education. The frequency of non-users increased from about 31% in 1975 to 49% in 1980; see also Table 1. This difference comes mainly from an increase in non-users among families with a higher parental education.

DISCUSSION

Retrospective information is difficult to obtain on the individual home practice pattern of preventive health measures, particularly over a considerable period. In this study a questionnaire was sent to each parent, since the common method of calculating the supply of fluoride tablets from pharmacy sales or collected prescriptions gives just an average picture of total consumption at different ages.

The present study showed that about 12% of the children had taken fluoride tablets according to existing directions in Sweden. The intake was substantially higher at lower ages. Half of the parents started to give their children tablets, but ceased to an increasing extent with rising age. This pattern of consumption can be said to resemble that reported in earlier Swedish investigations (2–5, 12) for children born in the late sixties. However, for children born in the early seventies there is less agreement with the present results, in that Forsman & Jacobson (12) reported an intake frequency of 80% in 4-year-olds born in 1972. As mentioned already, the consumption of fluoride tablets in the first half of the seventies was comparatively high in Norway. According to Lökken *et al.* (7), this may have been due to more intensive information.

In the period investigated, the present study indicates that the percentage of fluoride tablet users during preschool age has decreased by 18%, from 69 to 51%. The number of non-users increased mostly at the expense of sporadic consumers. The decrease largely agrees with the declining sale of fluoride tablets in this period, as reported by ACO Läkemedel AB (17), the largest producer of these tablets in Sweden. This circumstance might justify a nationwide generalization from the present investigation.

The low use of fluoride tablets and its falling trend may be a result of several factors. Primarily, this preventive measure calls for daily individual achievement over a very long period, which is not easy. Further, the diminishing use in Sweden in the seventies probably reflected the ongoing debate about the adequateness of supplying fluoride systemically. Mass media have had sceptical features about fluoride, and health and environmental movements, as well as a few scientists, have actively combatted a systemic supply. It may be indicative that more than half of the parents who had not given their children tablets or had ceased to do so, believe that fluoride administration can be harmful. This corresponds to 31% of the 1980 population. In this connection it is of interest that the opinion that fluoride may be harmful seems to have influenced families with a high parental education to a greater extent than other families. Furthermore, in this study, 13% of the parents who had never given their children tablets or had discontinued this, declared that tablets had never been recommended. Although information of this kind is not very easy to recall, the number of parents is too great to be ignored.

In conclusion, although science and authorities regard the caries-reducing effect of systemic fluoride administration as being of considerable value, at present it is obviously doubtful whether a public health measure could be achieved on a large scale by means of a tablet program based on parental responsibility. Better adherence to this preventive measure requires other, more effective means of providing the tablets, maybe in collective programs for day nurseries and the like. However, the present study does suggest that the topical use of fluoride in toothpaste and mouthrinse solution is well accepted in Sweden. In fact, an unexpectedly large number of children (45%) used a fluoride toothpaste before the recommended age of 4.

REFERENCES

1. Socialstyrelsen, SOSFS(M) 1977:26. Socialstyrelsens kungörelse om användning av fluorider i kariesprofylaktiskt syfte. Socialstyrelsens författningssamling.
2. Andersson, R. & Grahnén, H.: Fluoride tablets in preschool age – effect on primary and permanent teeth. *Swed. Dent. J.* 1976: *69:* 137–143.
3. Holm, A.-K.: Dental health in a group of Swedish 8-year-olds followed since the age of 3. *Community Dent. Oral Epidemiol.* 1978: *6:* 71–77.

4. HOLM, A.-K.: Oral health in 5-year-old Swedish children. *Community Dent. Oral Epidemiol.* 1975: *3:* 184–189.
5. MALMBERG, E.: Förskrivning av fria fluortabletter i Göteborgs kommun 1976. *Tandlaekartidningen* 1977: *68:* 968.
6. SOU (Statens offentliga utredningar) 1980:13, p. 145. Lönar det sig att tillsätta fluor i dricksvattnet? Rapport till fluorberedningen. Socialdepartementet, Stockholm.
7. LÖKKEN, P., ULVESTAD, H. & BIRKELAND, J. M.: Kariesprofylakse med fluortabletter i Norge. *Nor. Tannlaegeforen. Tid.* 1977: *87:* 309–311.
8. THYLSTRUP, A., FEJERSKOV, O., BRUUN, C. & KANN, J.: Enamel changes and dental caries in 7-year-old children given fluoride tablets from shortly after birth. *Caries Res.* 1979: *13:* 265–276.
9. NEWBRUN, E.: Systemic fluorides – an overview. *J. Can. Dent. Assoc.* 1980: *46:* 31–37.
10. MCENIERY, T. M. & DAVIES, G. B.: Brisbane Dental Survey, 1977 – A comparative study of caries experience of children in Brisbane, Australia over a 20-year period. *Community Dent. Oral Epidemiol.* 1979: *7:* 42–50.
11. HOLM, A.-K., BLOMQUIST, H. K., GROSSNER, C.-G., GRAHNÉN, H. & SAMUELSON, G.: A comparative study of oral health as related to general health, food habits and socioeconomic conditions of 4-year-old Swedish children. *Community Dent. Oral Epidemiol.* 1975: *3:* 34–39.
12. FORSMAN, B. & JACOBSON, D.: Faktorer som påverkar konsumtionen av fluortabletter. En undersökning bland 4-åringar i Växjö. *Tandlaekartidningen* 1977: *69:* 1339–1341.
13. SOU (Statens offentliga utredningar) 1981:32. Fluor i kariesförebyggnade syfte. Betänkande av fluorberedningen. Socialdepartementet, Stockholm.
14. KÖHLER, L. & HOLST, K.: Dental health of four-year-old children. *Acta Paediat. Scand.* 1973: *62:* 269–278.
15. MARTINSSON, T.: Socio-odontologic investigation of school children with high and low caries frequency. V. Socioeconomic factors and dental conditions in the parents. *Odontol. Revy* 1973: *24:* 59–74.
16. MÅNSSON, B., HOLM, A.-K., OLLINEN, P. & GRAHNÉN, H.: Dental health in 13-year-old children in the north of Sweden, changes during a 10-year-period. *Swed. Dent. J.* 1979: *3:* 193–203.
17. SAMUELSON, G., GRAHNÉN, H. & ARVIDSSON, E.: An epidemiological study of child health and nutrition in a northern Swedish county. VI. Relationships between general and oral health, food habits and socioeconomic conditions. *Am. J. Clin. Nutr.* 1971: *24:* 1361–1373.
18. ACO Läkemedel AB, 1981. Communication.

Paper 2

Model for the study of the preeruptive effect of NaF tablets on caries in permanent teeth

Jan Widenheim[1,4], Georg Lindgren[2], Lars Granath[1] and Dowen Birkhed[3]

Departments of Pedodontics[1], Mathematical Statistics[2] and Cariology[3], University of Lund and Department of Preventive Dentistry[4], Malmöhus County Council, Lund, Sweden

Widenheim J, Lindgren G, Granath L, Birkhed D: Model for the study of the preeruptive effect of NaF tablets on caries in permanent teeth. Community Dent Oral Epidemiol 1985; 13: 86–92.

Abstract – The purpose of this study was to elaborate a model for estimating the caries-reducing effect of a preventive measure with due consideration of background factors. The material comprised 50 children, who had consumed NaF tablets regularly during preschool age, and 76 comparable children who had never consumed NaF tablets. They were all examined at 12 and 13 yr of age. Information on caries and, as confounding factors, dietary habits, oral hygiene and microbiologic variables, was obtained on both occasions. Correlations between the parameters and caries, their discriminating effects and interaction between them were studied. The results showed that correction for confounding diminished the crude caries-reducing effect of NaF tablets. Streptococcus mutans and lactobacilli turned out to be the strongest confounders to discriminate well as single variables and to behave logically in analyses of interaction. Therefore, these factors are recommended in the first place for inclusion in a correction model. If the material is sufficiently large for a further breakdown, oral hygiene (represented by bleeding on probing) could be added. The model will be used in future studies of the preeruptive effect of NaF tablets on caries in permanent teeth in the same population.

Key words: dental caries; fluoride tablets; lactobacilli; microbiology, oral; Streptococcus mutans

J. Widenheim, Tandhälsovården, Gasverksgatan 17, S-252 25 Helsingborg, Sweden

Accepted for publication 20 March 1984

It is well known that people who grow up in places where consumption water contains approximately 1 ppm fluoride have substantially less caries than individuals exposed to water with, for instance, 0.1 ppm fluoride (1). The intake of tablets containing sodium fluoride (NaF) has been recommended as a substitute in areas with a low fluoride concentration in the drinking water. Caries reduction between 0 and 85% in permanent teeth has been reported after a daily intake of 0.25–2 mg fluoride in tablets for varying periods from shortly after birth up to the teens (2–10). However, although there is agreement about the posteruptive effect of fluoride tablets, the preeruptive effect was questioned recently (11).

In studies of the effect of preventive measures, comparisons should be made between individuals or groups of individuals with as similar characteristics as possible. Dental caries is a multifactorial disease, whose particular components are comparatively well elucidated. When estimating the value of a caries-preventive measure, it is therefore essential to analyze mechanisms of interaction, i.e. to correct for confounding factors (12, 13). While ideal conditions in this respect are easily obtained in controlled clinical trials of shorter duration by proper design of the investigation, practical and ethical obstacles arise in studies over longer periods. Furthermore, in a preventive program of combined procedures, the caries-inhibiting effect of one measure can be masked by that of another, especially if the latter is greater when used singly. Put another way, the effectiveness of a preventive measure is greatest when other factors are most unfavorable (13).

Such an analysis is clearly required when assessing the caries-preventive effect of NaF tablets. A positive correlation is to be expected between NaF tablet consumption and good oral hygiene and dietary habits, as ambitious parents are likely to strive continuously for good habits in their children. There are a few studies where the effect of fluoride tablets has been analyzed after correction for confounding factors. Granath *et al.* (13) reported, for instance, that the crude difference in proximal caries between 4-yr-old children, who had chewed tablets since before the age of 2, and children who had never chewed tablets, was about three times greater than the difference after correction for the confounding effect of diet and oral hygiene. In an investigation of children 15 yr of age by Tijmstra *et al.* (6), the caries difference between users and nonusers of NaF tablets during school age disappeared after a matching procedure to correct for socioeconomic variables, toothbrushing habits and consumption of sweets. Such analyses have seldom been included, however, in earlier studies on the effect of NaF tablets on permanent teeth after a daily intake during preschool age. Reported effects therefore should be evaluated with caution.

The principle aim of this study was to elaborate a model for the assessment of the caries-reducing effect of NaF tablets with due consideration of background factors. For this purpose, the preeruptive effect on caries in permanent teeth, exposed to posteruptive treatment with fluoride in toothpaste, mouthrinse sol-

ution and varnish, was studied. Children with a preschool intake of NaF tablets were compared to children who had never consumed tablets. Correction was made for variations in dietary habits, oral hygiene and microorganisms in saliva.

Material and Methods

Subjects

Information about preschool consumption of NaF tablets was collected from a questionnaire sent to parents of all children born in 1967 in Lund, Sweden. The municipal drinking water had a fluoride concentration of 0.2 ppm. All details regarding the questionnaire have been presented elsewhere (14). For the present study two groups were selected: **1**: children who, in accordance with directions from the National Swedish Board of Health and Welfare (15), had consumed NaF tablets daily for minimum 5 yr during the period ½–6 yr of age, here called the F^+-group, and **2**: children who had never consumed NaF tablets, here called the F^--group. The children in the F^--group belonged to the same school classes as those in the F^+-group. About 3% of the children refused to participate in the present investigation. The final sample consisted of 126 children, 50 in the F^+- and 76 in the F^--group. None of the children used tablets after the age of 7. They were examined in 1979 and again in 1980, at the ages of 12 and 13 yr, respectively. They all used fluoride toothpaste at home and participated in the regular mouthrinse program, using 0.2% NaF solution once a week during the school year. The permanent teeth had been treated with a fluoride varnish (Duraphat) once a year in both groups.

Potential confounding factors

Besides caries, a record was made of dietary habits, oral hygiene (represented by gingivitis and plaque), and microbiologic analyses of saliva samples (estimated numbers of Streptococcus mutans and lactobacilli). These variables were selected because they have been considered the most important confounding factors in caries studies.

It is clear from many investigations that intake of sugary foods correlates positively with dental caries, though the importance of eating habits has not yet been established in detail (16). Despite contradictory results from some studies regarding total sugar intake, the frequency of sugar consumption is considered to be of great importance for the occurrence of caries. This justified the use of a frequency measure in the present study.

The amount of plaque on teeth and along the gingival margin is an indicator of oral hygiene. Moreover, convincing evidence has been found for a relation between the amount of plaque and the incidence of periodontal disease, both in epidemiologic studies (17) and in experimental investigations (18, 19). Marginal gingivitis and dental plaque were consequently used as oral hygiene parameters in the present study. They have been considered important for caries (20–22), with due allowance for the effect of diet.

Several investigations have revealed in recent years that S. mutans plays an important role in the caries process (23–26), especially at the initiation of enamel caries lesions. Moreover, the well-known connection between the number of lactobacilli in saliva and the carbohydrate content of the diet (27) makes lactobacilli useful as a caries-predicting factor.

Dental caries

Recording of restorations and caries was confined to proximal surfaces, diagnosed by means of bitewing radiographs. Orthoradial projection against the second premolar or, if this tooth has not erupted, the primary second molar was used in 1979, one film on each side. In 1980, two films were exposed on each side, after projection against the second premolar and the permanent first molar. All pictures were taken by one of us (J.W.). Proximal caries was defined as radiolucent areas that could not be related to normal anatomy or hypoplasia (28). All films were evaluated simultaneously by two of us (J.W. and L.G.) with the aid of a magnifying viewer (29). A second determination of a random sample, covering about 1/5 of the total material in 1979, was done after 7 months. It showed 96% agreement with the primary registration concerning caries/not caries. All registrations were made without knowing whether the radiographs belonged to the F^+- or the F^--group. In the 1979 material only the mesial surface of permanent first molars was used. In 1980, the proximal surfaces were registered from the mesial surface of the permanent second molar to the distal surface of the first premolar, maximum 24 surfaces per subject. In order to overcome the effect of variations in the number of erupted teeth in the 1980 material, the caries increment was recorded as the number of surfaces that had become carious since 1979, expressed as a percentage of the number of available surfaces at the end of the period minus those that had been carious and filled at the start. A tooth was considered erupted when any part of the crown had perforated the oral mucosa.

Dietary habits

All children were interviewed for about 30 min in groups of four and had to fill in a questionnaire, supervised by one of us (J.W.). The frequency of intake of the following sugar-containing meals and snacks during an "ordinary" week was estimated: soft drinks or juices, carbonated beverages, sweetened cocoa-drinks, Danish pastries or sweetened buns, cakes or biscuits, bread with marmelade or jam, frosted flakes, raisins, ice-cream, lozenges, chewing gums and sweets. A mean daily intake of these items for the individual child was obtained by dividing the total number of intakes per week by seven and was used as an expression of dietary habits (D).

Oral hygiene

In the 1979 material, oral hygiene was assessed by partial registration of the gingival state. Registration was made on buccal, mesial and lingual surfaces of maxillary right and mandibular left permanent first molars and on buccal, distal and lingual surfaces of maxillary left and mandibular right first premolars, maximum 12 areas per subject. A feather-loaded periodontal probe (30) with standardized load (0.27 N) was used. The tests were carried out by one of us (L.G.). If bleeding occurred within 1 min after probing the gingival crevice, gingivitis was said to prevail. The number of bleeding points was expressed as the share of the number of available surfaces and used as an oral hygiene criterion (H_1). In 1980, the registration procedure with the feather-loaded probe failed on account of a technical hitch. Instead, the situation in 1980 was represented in this study by

the mean of values for 1979 and 1981, since the 1981 values were available at the time of analysis.

In 1980, registration of plaque formation was included as another measure of oral hygiene (H_2). After the teeth had been painted with a disclosing solution (Rondell röd, LIC, Solna, Sweden), followed by rinsing with water, premolars and permanent first molars were scored "plaque-coated" when the buccal surface had an unbroken area of stained material from the mesial to the distal surface of the tooth. The number of teeth registered with plaque was expressed as a percentage of the number of available surfaces, maximum 12 areas/subject. One of us (D.B.) was responsible for these examinations.

Microbiologic factors

Estimation of the number of S. mutans and lactobacilli in the saliva was carried out in 1979 and 1980. Paraffin-stimulated saliva samples of approximately 2 ml were collected from all children in connection with the clinical registration. The sample was shaken vigorously for 30 s in a mechanical mixer. One ml saliva from each sample was immediately transferred to a sterile test tube containing 4 ml VMG II transport medium (31). Bacteriologic culturing was performed within 24 h after collection. The suspension was diluted in 10-fold steps in 0.02 M sodium phosphate buffer (pH 7.2) with 0.4% (w/v) NaCl. From suitable solutions, cultivation was performed on the following media: 1) Mitis Salivarius Bacitracin (MSB) agar incubated in a mixture of 5% CO_2 and 95% N_2 at 37°C for 2 days, and 2) Rogosa selective lactobacillus (SL) agar with a poured plate technique, incubated aerobically for 4 days at 37°C. On MSB agar the colony forming units (CFU) with morphology characteristic for S. mutans were counted and expressed as number per ml saliva (M). On SL agar, all CFU were counted and considered to be lactobacilli (L), expressed as number per ml saliva.

Statistical design

The goal for the statistical analysis was to measure to what extent the reduction of caries observed between the F^-- and F^+-group could be explained by dietary, oral hygiene or microbiologic factors as registered in the present study. In the design of the analysis it was considered important to avoid a detailed mathematical model for the exact influence of the various factors. A multiple regression model, for instance, would have to contain non-linear terms (such as products of factors), which would easily lead to difficulties in interpretation. A second condition for the analysis was that its results should be interpretable in terms of a reduction in the total amount of caries in a specified or hypothetical population.

Table 1. Model for analysis of interaction; two variables dichotomized into "less favorable" (−) and "favorable" (+) proportions; differences between − − and − + and between + − and + + used for calculation of a weighted mean difference

		Variable 1	
		−	+
Variable 2	−	− −	− +
	+	+ −	+ +

Criteria were also set up for correction for confounding. The subjects were dichotomized with respect to each of the variables, into "less favorable" and "favorable" fractions. This was accomplished in the following way. First, we tried to establish logical borders with due consideration of critical levels found in the literature, which particularly applied to diet, S. mutans and lactobacilli. More than two bleeding units out of 12 were definitely said to be less favorable. Second, the borders had to be slightly modified in order to obtain a fairly equal distribution between the two fractions, permitting further subgrouping of practical value. This latter procedure affected the border of the plaque variable more than those of the other variables. The discriminatory borders were as follows:

D^-: ≥3.5 and D^+: <3.5 mean daily intakes of sugar-containing meals and snacks;

H_1^-: >17% and H_1^+: ≤17% bleeding units, out of selected gingival areas available for registration;

H_2: ≥39% and H_2^+: <39% teeth coated with plaque, out of selected teeth available for registration;

M^-: ≥5.4 and M^+: <5.4 (5.4 = log 250 000 CFU/ml saliva);

L^-: ≥3.7 and L^+: <3.7 (3.7 = log 4500 CFU/ml saliva).

The analysis of 1980 data was made on individual mean values of dietary habits, S. mutans and lactobacilli from the examinations in 1979 and 1980 together with mean values of gingival state in 1979 and 1981 (see above) and plaque values in 1980. First, the crude differences in caries between the groups, dichotomized according to different variables, including fluoride consumption, were calculated in order to reveal the single discriminative effects. In this connection the coefficients for the correlation between caries and the respective variables, fluoride excluded, were also calculated. Thereafter, corrections for confounding factors were performed in serial steps. The size of the material permitted correction for not more than two confounders. Analysis of the interaction effect of two variables on caries was performed in four-fold contingency tables, as outlined in Table 1. In a perfect interaction between the variables, − − is supposed to have the most and + + the least disease. The numerical difference between + − and + + should be less than between − − and − +, as the effect of a preventive measure is supposed to be greatest

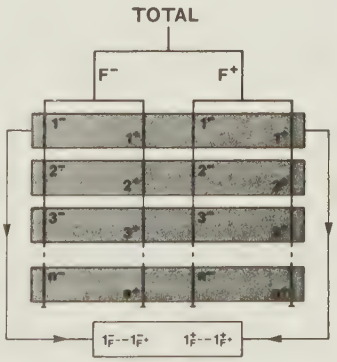


Fig. 1. Diagram showing scheme of correction for one confounder at a time; weighted mean differences calculated according to Table 1 and the formula for $diff_{mean}$; F^- = no intake, F^+ = regular intake of NaF tablets; 1...n = number of confounders; − = less favorable, + = favorable.

when other factors are the most unsuitable (13). The same applies to the difference between $-+$ and $++$ compared to that between $--$ and $+-$. It was decided that the ranking of confounders should be based on, first, their discriminating power as single factors and, second, their ability to interact in a logical way with fluoride and with each other.

The serial-step analysis for calculating mean differences between F^- and F^+ subgroups is demonstrated in Fig. 1, showing correction for one confounder at a time, and in Fig. 2, showing correction for two confounders simultaneously. For each subgroup formed by one or two confounders, the difference between the F^-- and the F^+-children was calculated together with the standard error of the difference. It is these differences that form the basis for the discussion of the effect of fluoride tablets in a real or a hypothetical population. As a crude summary, a weighted average difference, $diff_{mean}$, of the subgroup differences, $diff_k$, was calculated according to the formula

$$diff_{mean} = \frac{\Sigma\ diff_k/s_k^2}{\Sigma\ 1/s_k^2}$$

where s_k is the standard error of the difference.

Results

In 1979, the mean values of mesial DF surfaces of the permanent first molars were 1.68 in the F^--group and 1.02 in the F^+-group. Thus, the non-corrected difference between these subgroups was 0.66 and turned out to be the third in size after those of lactobacilli and S. mutans (Table 2). The corresponding increment value of proximal surfaces in 1980 was 3.12, the mean values of the F^-- and the F^+-group being 7.65 and 4.53, respectively. However, in 1980 the non-corrected differences were greater between the respective H_I-, M- and L-subgroups than between the F-subgroups (Table 3).

The correlations between single parameters and caries were weak (Table 4). As an example, the relationship between dietary habits and caries in 1980 is demonstrated in Fig. 3.

As the size of the material did not permit correction for more than two confounders and the r value and the discriminating effect of diet and plaque, respectively, were low, these two parameters were omitted in the subsequent analyses.

Tables 5 and 6 present caries mean values of different subgroups, composed of two or three factors, illustrating the power of the same factors as well as the

Table 2. Crude differences (d) between mean values ($\bar{x}$) and standard error of the differences (SE_d) of DF mesial surfaces of permanent first molars in subgroups ($-$ = less favorable, $+$ = favorable) of different variables (fluoride tablets (F), diet (D), oral hygiene (H), S. mutans (M), and lactobacilli (L)); H_I estimated through number of bleeding gingival units; number of subjects within parentheses; 1979 material

	$d_{\bar{x}}$	SE_d	Reduction in %
F^- vs F^+	1.68(76)–1.02(50) = 0.66	0.25	39.3
D^- vs D^+	1.55(67)–1.27(59) = 0.28	0.26	18.1
H_I^- vs H_I^+	1.69(64)–1.15(62) = 0.54	0.25	32.0
M^- vs M^+	1.84(55)–1.10(71) = 0.74	0.26	40.2
L^- vs L^+	1.85(54)–1.10(72) = 0.75	0.26	40.5

Table 3. Crude differences (d) between mean values ($\bar{x}$) and standard error of the differences (SE_d) of DF proximal surfaces (from mesial surface of permanent second molars to distal surface of first premolars) in subgroups ($-$ = less favorable, $+$ = favorable) of different variables (fluoride tablets (F), diet (D), oral hygiene (H), S. mutans (M), and lactobacilli (L); H_I estimated through number of bleeding gingival units, H_2 through presence of plaque; number of subjects within parentheses; $\bar{x}$ = increments between 1979 and 1980 in percent of available surfaces during the year

	$d_{\bar{x}}$	SE_d	Reduction in %
F^- vs F^+	7.65(69)–4.53(50) = 3.12	2.70	40.8
D^- vs D^+	6.85(59)–5.84(60) = 1.01	2.77	14.7
H_I^- vs H_I^+	8.07(69)–4.21(47) = 3.86	2.73	47.8
$H_{\bar{x}}^-$ vs $H_{\bar{x}}^+$	7.22(52)–5.66(67) = 1.56	2.60	21.6
M^- vs M^+	9.46(61)–3.06(58) = 6.40	2.66	67.7
L^- vs L^+	7.88(77)–3.52(42) = 4.36	2.25	55.3

Table 4. Coefficients of correlations (r) between single parameters and caries; for abbreviations see Table 3

	r, 1979	r, 1979/1980
D	0.104	0.125
H_1	0.143	–
H_2	–	0.055
M	0.263	0.189
L	0.261	0.275

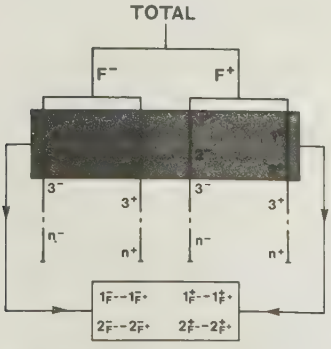


Fig. 2. Diagram showing scheme of correction for two confounders simultaneously; otherwise refer to Fig. 1.

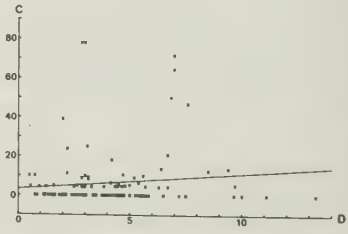


Fig. 3. Correlation between caries increment (C), in percent of available tooth surfaces, and dietary habits (D), measured as mean daily intake of sugar-containing meals and snacks during 1979–80; r = 0.13.

weaknesses in a clinical material of this type. The ability to interact in a logical way was about the same for oral hygiene (H_1), S. mutans and lactobacilli. Weighted mean differences between F^-- and F^+-subgroups are given in Table 7.

The results showed that S. mutans was the strongest confounder and that lactobacilli ranked second and oral hygiene third in both 1979 and 1980.

Discussion

The present investigation constituted a search for a model with which to evaluate the preeruptive effect of NaF tablets on caries in permanent teeth. Control of confounding factors in analytical epidemiology calls for parameters with high validity. In caries research, it is natural to look for such parameters for dietary habits and oral hygiene. Five variables with a well-documented relationship to caries were included in this study. As shown under Results, the diet and plaque factors were omitted later because their discriminating effect proved to be low.

The difficulty of finding a parameter for dietary habits that is suitable for the prediction of caries is clear from many investigations (16). One explanation for the weak correlation between caries and diet in the present study might be that the information from the interviews could be elusive or not representative for the period in question. It is difficult to know whether the low discriminating effect is real or secondary to the method used.

The low discriminating effect of the plaque variable is easier to explain. In an earlier study by GRANATH *et al.* (13) it was found that 4-yr-old children, who did not practice oral hygiene, had substantially more proximal caries than those on whom toothbrushing was used. The probable reason for this was that in many instances the entrances to the interproximal spaces were covered with plaque in the first group. However, in cases with reasonable oral hygiene, contacting teeth and a normally situated gingival margin, it is almost impossible to register plaque where caries starts in proximal surfaces. In the further assessment, oral hygiene, as reflected by gingival bleeding on probing, S. mutans and lactobacilli were found to discriminate well as single variables and to behave logically in the analyses of interaction. S. mutans showed the greatest discriminat-

Table 5. Caries mean values of different subgroups composed of the fluoride tablet variable and one of the variables oral hygiene, S. mutans, and lactobacilli, respectively; number of subjects within parentheses; for abbreviations and definition of caries, see Tables 2 and 3

		1979	1980
F	H_1		
+	+	0.93 (28)	4.48 (25)
+	−	1.14 (22)	4.78 (24)
−	+	1.32 (34)	3.90 (22)
−	−	1.98 (42)	9.83 (45)
F	M		
+	+	0.90 (38)	3.98 (30)
+	−	1.42 (12)	5.36 (20)
−	+	1.33 (33)	2.08 (28)
−	−	1.95 (43)	11.46 (41)
F	L		
+	+	0.79 (33)	2.81 (22)
+	−	1.47 (17)	5.89 (28)
−	+	1.36 (39)	4.30 (20)
−	−	2.03 (37)	9.02 (49)

Table 6. Caries mean values of different subgroups composed of the fluoride tablet variable and two of the variables oral hygiene, S. mutans, and lactobacilli, respectively; number of subjects within parentheses; for abbreviations and definition of caries, see Tables 2 and 3

			1979	1980
F	H_1	M		
+	+	+	0.86 (21)	2.27 (11)
+	+	−	1.14 (7)	6.21 (14)
+	−	+	0.94 (17)	5.25 (18)
+	−	−	1.80 (5)	3.37 (6)
−	+	+	1.15 (20)	1.74 (11)
−	+	−	1.57 (14)	6.06 (11)
−	−	+	1.62 (13)	2.44 (16)
−	−	−	2.14 (29)	13.90 (29)
F	H_1	L		
+	+	+	0.79 (19)	1.99 (13)
+	+	−	1.22 (9)	7.18 (12)
+	−	+	0.79 (14)	4.01 (9)
+	−	−	1.75 (8)	5.24 (15)
−	+	+	1.09 (22)	4.19 (9)
−	+	−	1.75 (12)	3.69 (13)
−	−	+	1.71 (17)	4.82 (10)
−	−	−	2.16 (25)	11.26 (35)
F	M	L		
+	+	+	0.90 (29)	3.35 (17)
+	+	−	0.89 (9)	4.82 (13)
+	−	+	0.00 (4)	1.00 (5)
+	−	−	2.13 (8)	6.81 (15)
−	+	+	1.30 (23)	2.98 (13)
−	+	−	1.40 (10)	1.29 (15)
−	−	+	1.44 (16)	6.74 (7)
−	−	−	2.26 (27)	12.43 (34)

Table 7. Weighted mean differences ($\bar{x}$) and standard errors (SE) between F^- and F^+ subgroups after correction for one or two of the variables oral hygiene, S. mutans, and lactobacilli; for abbreviations and definition of caries, see Tables 2 and 3

	1979		1980	
	$\bar{x}$	SE	$\bar{x}$	SE
M	0.47	0.27	1.95	2.78
L	0.57	0.26	2.52	2.82
H_1	0.61	0.26	2.64	2.90
$M+H_1$	0.43	0.27	0.98	2.99
M+L	0.49	0.26	1.73	2.83
$L+H_1$	0.53	0.26	2.13	2.95

Crude difference between F^- and F^+ in 1979 = 0.66, in 1980 = 3.12.

ory effect in 1980 and lactobacilli in 1979. The two microorganisms can be said to meet the requirement of a causal relationship with caries, S. mutans representing caries-inducing bacteria and lactobacilli consumption of sugar. These two factors were to a certain extent related to oral hygiene ($r = 0.21$ and 0.24, respectively, in the 1979 material). Moreover, they can be registered by objective methods, which has evident advantages.

Gingival bleeding on probing also turned out to be a usable factor. Together with S. mutans, it exerted the strongest correction of the crude difference between the F^-- and the F^+-group in 1980. However, as both S. mutans and lactobacilli also to some extent mirror oral hygiene and, above all, lactobacilli reflect sugar consumption, these two variables should be preferred in further studies of the preeruptive effect of NaF tablets on caries in permanent teeth, as long as the number of subjects limits correction to two factors.

The frequencies of S. mutans and lactobacilli in the present study correspond relatively well to data from other Swedish investigations on children of the same age. In a study by KLOCK & KRASSE (32) the median values were 6.4×10^5 for S. mutans and 1.0×10^4 for lactobacilli, respectively, in children 9–12 yr of age. ZICKERT *et al.* (33) reported 2.6×10^5 and 0.8×10^4, respectively, as median values in 13–14-yr-olds. These values correspond roughly to the discriminatory borders in the present study, which were 2.5×10^5 and 4.5×10^3 for S. mutans and lactobacilli, respectively.

When evaluating the 1979 material it should be borne in mind that the prevalence of caries on mesial surfaces of the permanent first molars represents the total caries increment since eruption, no doubt with varying levels of background factors during the period up to the investigation. Furthermore, molars that erupted early could have been influenced by a topical effect of the tablets during a period in the F^+-group.

It must be emphasized that the type of analysis in this study is conservative in the sense that if it shows that some of the estimated effect of fluoride can be attributed to interacting factors, then the true effect of fluoride can certainly not be higher than that obtained after correction.

In conclusion, the purpose of this study was to construct a model for estimating, as fairly as possible, the preeruptive effect of fluoride tablets on caries in permanent teeth. Several factors of importance for dental caries were examined with respect to their discriminatory effect and behavior in interaction systems. In subsequent reports on the population in question, the numbers of S. mutans and lactobacilli will be used to correct the crude effect of fluoride tablets. For further studies of the effect of particular preventive measures, it is recommended that these two factors are used as primary confounders, followed by bleeding on probing, provided the material is large enough for more than two confounders and as long as a strongly discriminating parameter of diet has not been found.

References

1. BACKER-DIRKS O, KÜNZEL W, CARLOS JP. Caries-preventive water fluoridation. *Caries Res* 1978; *12:* Suppl 1: 7–14.
2. DRISCOLL WS. The potential benefits to be derived from fluoride tablets. In: FORRESTER DJ, SCHULZ EM, eds. *International workshop on fluorides and dental caries reductions*. Baltimore: University of Maryland, 1974; 25–93.
3. BINDER K, DRISCOLL WS, SCHÜTZMANNSKY G. Caries-preventive fluoride tablet programs. *Caries Res* 1978; *12:* Suppl 1: 22–30.
4. HAUGEJORDEN O, HELØE LA. Fluorides for everyone: a review of school-based or community programs. *Community Dent Oral Epidemiol* 1981; *9:* 159–69.
5. ANDERSSON R, GRAHNÉN H. Fluoride tablets in pre-school age – effect on primary and permanent teeth. *Swed Dent J* 1976; *69:* 137–43.
6. TIJMSTRA T, BRINKMAN-ENGLES M, GROENEVELD A. Effect of socioeconomic factors on the observed caries reduction after fluoride tablet and fluoride toothpaste consumption. *Community Dent Oral Epidemiol* 1978; *6:* 227–30.
7. BERNSTEIN M. Modell der Kariesprävention im Kreis Gardelegen mit Tabletten- und Trinkwasserfluoridierung sowie überwachter Mundhygiene. *Stomatol DDR* 1979; *29:* 282–7.
8. MCENIERY TM, DAVIES GN. Brisbane Dental Survey, 1977 – A comparison study of caries experience of children in Brisbane, Australia over a 20-year period. *Community Dent Oral Epidemiol* 1979; *7:* 42–50.
9. THYLSTRUP A, FEJERSKOV O, BRUUN C, KANN J. Enamel changes and dental caries in 7-year-old children given fluoride tablets from shortly after birth. *Caries Res* 1979; *13:* 265–76.
10. POULSEN S, GADEGAARD E, MORTENSEN B. Cariostatic effect of daily use of a fluoride-containing lozenge compared to fortnightly rinses with 0.2% sodium fluoride. *Caries Res* 1981; *15:* 236–42.
11. FEJERSKOV O, THYLSTRUP A, LARSEN MJ. Rational use of fluorides in caries prevention. A concept based on possible cariostatic mechanisms. *Acta Odontol Scand* 1981; *39:* 241–9.
12. MIETTINEN O. Confounding and effect-modification. *Am J Epidemiol* 1974; *100:* 350–3.
13. GRANATH L, ROOTZÉN H, LILJEGREN E, HOLST K, KÖHLER L. Variation in caries prevalence related to combinations of dietary and oral hygiene habits and chewing fluoride tablets in 4-year-old children. *Caries Res* 1978; *12:* 83–92.
14. WIDENHEIM J. A time-related study of intake pattern of fluoride tablets among Swedish preschoolchildren and parental attitudes. *Community Dent Oral Epidemiol* 1982; *10:* 296–300.
15. SOCIALSTYRELSEN. Socialstyrelsens kungörelse om användning av fluorider i kariesprofylaktiskt syfte. *SOSFS(M)* 1977: 26.
16. SREEBNY LM. Sugar and human dental caries. *World Rev Nutr Diet* 1982; *40:* 19–65.
17. BRANDTZAEG P. The significance of oral hygiene in the prevention of dental diseases. *Odontol Tidskr* 1964; *72:* 460–86.
18. KOCH G, LINDHE J. The effect of supervised oral hygiene on the gingiva of children. *Odontol Revy* 1965; *16:* 327–35.
19. LÖE H, THEILADE E, JENSEN SB. Experimental gingivitis in man. *J Periodontol* 1965; *36:* 177–87.
20. FEHR FR VON DER, LÖE H, THEILADE E. Experimental caries in man. *Caries Res* 1970; *4:* 131–48.
21. GRANATH L-E, SCHRÖDER U. Explanatory model for the interaction of factors in the caries process. *Acta Odontol Scand* 1978; *36:* 253–6.
22. GRANATH L-E, MARTINSSON T, MATSSON L, NILSSON G, SCHRÖDER U, SÖDERHOLM B. Intraindividual effect of daily supervised flossing on caries in schoolchildren. *Community Dent Oral Epidemiol* 1979; *7:* 147–50.
23. IKEDA T, SANDHAM HJ, BRADLEY EL, JR. Changes in Streptococcus mutans and lactobacilli in plaque in relation to the initiation of dental caries in Negro children. *Arch Oral Biol* 1973; *18:* 555–66.
24. LOESCHE WJ, ROWAN J, STRAFFON LH, LOOS PJ. Association of Streptococcus mutans with human dental decay. *Infect Immun* 1975; *11:* 1252–60.
25. VAN HOUTE J. Bacterial specificity in the etiology of dental caries. *Int Dent J* 1980; *30:* 305–26.
26. HAMADA S, SLADE HD. Biology, immunology and cariogenicity of Streptococcus mutans. *Microbiol Rev* 1980; *44:* 331–84.

27. ELLEN RP. Microbiological assays for dental caries and periodontal disease susceptibility. *Oral Sci Rev* 1976; *8:* 3–23.
28. GRANATH L-E, HOLST K, OMNELL K-Å. Effekten av information i tandhälsovård i samband med hälsokontroll av 4-åringar – (forts). IV. Kariesförekomst. V. Sammanfattande diskussion. *Sven Tandlaek Tidskr* 1971; *64:* 175–84.
29. MATTSSON O. A magnifying viewer for photofluorographic films. *Acta Radiol* 1953; *39:* 412–4.
30. ASBOE-JÖRGENSEN V, ATTSTRÖM R, LANG NP, LÖE H. Effect of chlorhexidine dressing on the healing after periodontal survey. *J Periodontol* 1974; *45:* 13–7.
31. MÖLLER ÅJR. *Microbiological examination of root canals and periapical tissues of human teeth. Methodological studies.* Thesis. Gothenburg: Akademiförlaget, 1966.
32. KLOCK B, KRASSE B. Microbial and salivary conditions in 9- to 12-year-old children. *Scand J Dent Res* 1977; *85:* 56–63.
33. ZICKERT I, EMILSON CG, KRASSE B. Streptococcus mutans, lactobacilli and dental health in 13–14-year-old Swedish children. *Community Dent Oral Epidemiol* 1982; *10:* 77–81.

Paper 3

Preeruptive effect of NaF tablets on caries in children from 12 to 17 yr of age

JAN WIDENHEIM[1,4], DOWEN BIRKHED[2], LARS GRANATH[1] and GEORG LINDGREN[3]

Departments of Pedodontics[1], Cariology[2] and Mathematical Statistics[3], University of Lund and Department of Preventive Dentistry[4], Malmöhus County Council, Lund, Sweden

Running title: Effect of NaF tablets

Jan Widenheim, Tandhälsovården, Gasverksgatan 17, S-252 25 Helsingborg, Sweden

Widenheim J, Birkhed D, Granath L, Lindgren G: Preeruptive effect of NaF tablets on caries in children from 12 to 17 yr of age. Community Dent Oral Epidemiol 1985; 13:000.

Abstract - The purpose of this study was to evaluate the preeruptive effect of NaF tablets on caries in proximal surfaces of permanent molars and premolars. The material consisted of 47 subjects, who had consumed fluoride tablets for minimum 5 yr between ½ and 6 yr of age in accordance with recommendations from the National Swedish Board of Health and Welfare (F^+-group) and 69 comparable children who had never consumed such tablets (F^--group). All had resided since birth in an area with a water fluoride concentration of 0.2 ppm and had been exposed to fluorides in toothpaste, mouthrinse solution and varnish since at least the age of 6. The children were examined by means of bitewing radiographs at the ages of 12, 13, 14 and 17. Two confounding factors, i.e. salivary counts of *Streptococcus mutans* and lactobacilli, were estimated and used for correction of crude caries differences. The mean values of these factors were higher in the F^--group than in the F^+-group. The results showed a statistically significantly higher caries prevalence in the F^--group compared to the F^+-group when the children were 14 yr old, 4.4 vs. 2.9 DFS, corresponding to a caries reduction of about 34 %. After correction for confounding, this was reduced to 24 %, representing a non-significant difference of 1.1 DFS but still indicating a preeruptive effect. At the age of 17, the difference in caries prevalence was statistically not significant, 7.1 vs. 5.6 DFS, corresponding to a reduction of 21 %. Based on corrected data, this was reduced to 15 %. A main finding was that caries reduction diminished with time.

Key words: dental caries; prevention; fluoride tablets; lactobacilli; Streptococcus mutans.

J. Widenheim, Tandhälsovården, Gasverksgatan 17, S-252 25 Helsingborg, Sweden

Nearly 40 studies have been published on the caries-preventive effect of sodium fluoride (NaF) tablets on permanent teeth (1-3), reporting caries reduction figures from 0 to 80 %, with a median of about 30 %. Such a range should be expected, as there are great variations in population characteristics, caries prevalence, diagnostic criteria, type of fluoride preparation and dosage, and also in initial age, duration and mode of tablet consumption. Moreover, as administration of NaF tablets usually is aimed at both systemic (preeruptive) and topical (posteruptive) influences on teeth, like those of fluoridated drinking water, it has been difficult to separate these two effects. It seems, however, that the median reduction is somewhat higher, 55 %, if the calculation is restricted to studies (4-11) where tablet consumption started at a very early age, i.e. during the main formative period of the permanent teeth (Table 1).

The mechanisms of fluoride in caries prevention are difficult to rank by clinical significance. Improved cristallinity, implying reduced solubility, obtained through a preeruptive fluoride supply during mineralization of the enamel, has been said to be essential (12,13). There is, however, only meagre evidence that this property substantially influences the occurrence of caries in the long term compared to the posteruptive effect of fluoride. It has recently been suggested that fluoride's preeruptive effect on caries is negligible compared to its posteruptive effect (14,15). Clearcut knowledge about the caries-preventive effect of a systemic supply of fluoride in tablets is important for the planning of efficient community health measures in fluoride deficient areas.

When assessing the effect of a caries-preventive measure, it is essential to consider the multifactorial nature of caries. This has seldom been done in earlier studies. In a previous investigation (16), a model was developed for the evaluation of the preeruptive effect of NaF tablets on permanent teeth. It was concluded that the chief confounding factors, to be used for correcting the crude cariostatic effect of fluoride tablets, are salivary counts of *Streptococcus mutans* and lactobacilli.

The aim of the present investigation was to estimate the preeruptive caries-reducing effect of NaF tablets on caries in proximal surfaces of posterior teeth in children from 12 to 17 yr of age with

consideration of the above background factors. Caries data for children who had regularly used NaF tablets for minimum 5 yr from their first year of life, were compared with data for children who had never taken such tablets. The study was carried out in a low-fluoride area, where all children from the age of 6 participated in a basic caries-preventive program, including fluoride-containing toothpaste, mouthrinses and varnish.

MATERIAL AND METHODS

Subjects

The selection of subjects has been described in detail previously (16,17). From their birth in 1967 all the children had resided in the city of Lund, Sweden, where the concentration of fluoride in the drinking water is 0.2 ppm. They were examined in 1979, 1980, 1981 and 1984, at the ages of 12, 13, 14 and 17. In 1981, 49 children remained from the original 50 who, in accordance with recommendations from the National Swedish Board of Health and Welfare (18), had taken 1 NaF tablet (0.25 mg F) daily before 1 yr of age and two tablets thereafter, for minimum 5 yr during the period ½-6 yr of age (F^+-group), and 69 children from the original 76 who had never consumed NaF tablets (F^--group). The drop-out was due to departure from the district (3 children) or failure to come to the examination (5 children). In 1984, further 2 subjects in the F^+-group had moved. Most children in the F^+-group had discontinued the consumption of fluoride tablets at the age of 6, and all of them had stopped at seven. From the age of 6 the children had participated in a regular mouthrinse program, using 0.025 % NaF solution initially and 0.2 % solution from the age of 7 once a week during school terms. Their permanent teeth had been treated with a fluoride varnish (Duraphat®) approximately once a year. In addition, since preschool age they had used fluoride toothpaste daily at home.

Dental caries

Caries and restorations of permanent teeth were diagnosed as described in detail previously (16). Proximal surfaces from the mesial surface of the permanent second molar to the distal surface of the first

premolar, maximum 24 surfaces, were examined on bitewing radiographs. In 1979, one film was used on each side, in 1980, 1981 and 1984 two films. The incidence of caries in each child was recorded separately for the periods 1979-80 and 1980-81 as the number of decayed or filled surfaces minus the number that had been decayed or filled at the beginning of the period. The prevalences in 1981 and 1984 were calculated by adding the incidences to the prevalence in 1979.

Confounding factors

The salivary counts of *S. mutans* and lactobacilli were used as confounding factors (16). Saliva samples were collected in connection with the clinical examinations in 1979, 1980 and 1981. Unfortunately, the salivary samples in 1981 were diluted incorrectly and had to be repeated about half a year later. The individual numbers of *S. mutans* (M) and lactobacilli (L) per ml saliva were determined according to KLOCK & KRASSE (19).

In order to check whether these bacteria were suitable as confounders, the differences were calculated between the mean counts of the F^-- and F^+-groups in each period.

For different reasons, saliva samples could not be collected in 1984.

Statistical design

The principal aim of the statistical analyses was to estimate the caries difference between the F^-- and F^+-groups before and after correction for the confounding factors, i.e. by means of crude and weighted mean differences, as described by Widenheim *et al.* (16). Mean caries values were calculated both including and excluding permanent first molars, as fluoride in the tablets could be expected to have exerted a topical influence on these teeth around the age of 6.

The subjects were dichotomized into "less favourable" (M^- and L^-) and "favourable" (M^+ and L^+) subgroups, using the following discriminatory borders:

M^-: $\geq$ 5.4 and M^+: $<$ 5.4 (5.4 = log 250,000 CFU/ml saliva);
L^-: $\geq$ 3.7 and L^+: $<$ 3.7 (3.7 = log 4,500 CFU/ml saliva).

In the correction procedure, the salivary counts of *S. mutans* and lactobacilli in 1979, and the mean counts of each of these bacteria in 1979-80 and 1980-81, were used to correlate the corresponding caries values with as time-related microbial data as possible.

The analyses of caries data were performed as one-tailed t tests or approximate normal tests. This was done because it was clear from the material that any real difference would be in favour of the F^+-group. On the other hand, two-tailed tests were applied when analysing differences between the F^--and F^+-groups in respect of M- and L-values. Differences at the 5 % level of probability were considered to be statistically significant.

RESULTS

12 - 14-yr-period

The analyses showed that caries was less prevalent in the F^+-group compared to the F^--group at the age of 14. Fourteen % of the children in the F^--group and 33 % in the F^+-group were caries-free. The difference between the mean values of the F^-- and F^+-groups was 1.5 DFS before correction for confounding and 1.1 DFS after (Table 2). These differences correspond to caries reductions of 34 and 24 %. The crude difference is statistically significant, while the corrected one is not. Excluding the first molars, the differences were 0.7 and 0.5 DFS, corresponding to reductions of 36 and 24 %. Here, the crude difference is almost statistically significant, but the corrected one is not.

The major part of the caries difference between the groups had been attained at the age of 12 and predominently concerned the first molars (Table 2). The incremental differences in the period from 12 to 13 yr of age were low, irrespective of whether first molars were included or not. During the second incremental period there was practically no caries reduction.

Table 3 shows that the mean values of the microbial factors were higher in the F^--group compared to the F^+-group, with statistical significance in 1979 and during the period 1979-80, but not in 1980-81.

14 - 17-yr-period

At the age of 17, 14 subjects in the F^+-group were caries-free compared to 11 in the F^--group, corresponding to 30 and 16 %, respectively. There was a mean of 7.1 proximal DFS in the F^-- and 5.6 in the F^+-group. The difference, 1.5 DFS (SE = 1.20), corresponds to a crude caries reduction of 21 % ($p > 0.05$). The percentage difference was about the same after exclusion of first molars, based on means of 3.8 DFS in the F^-- and 3.0 DFS in the F^+-group (SE of difference between means = 0.75; $p > 0.05$).

The caries increment between 1981-84 was the same in the two groups, 2.6 DFS. This means that a corrected caries reduction of 15 % could be calculated for the age of 17 by using the weighted mean difference 1.1 DFS from 1981 (Table 2).

DISCUSSION

The results of the present study show that the 17-yr-old subjects who had consumed NaF tablets for minimum 5 yr between ½ and 6 yr of age, but not after 7, had a lower prevalence of caries than those who had not taken tablets. Calculated on uncorrected data at the age of 14, the caries reduction of about 34 % was statistically significant. Although not significant, a reduction of about 24 % remained after correction for confounding, irrespective of whether first molars were included or not, which indicates a "true" preeruptive effect of NaF tablets. Of the absolute weighted mean difference of 1.1 DFS, about half was attributable to the first molars, suggesting that these teeth may also have benefitted from a topical effect of the tablets.

Since the caries increment between 1981-84 was the same in the two groups, a corrected percentage reduction could be calculated for the age of 17 in spite of lack of background data for the period. This implies a decrease from 24 % at the age of 14 to 15 % at the age of 17.

We consider that, with the design of the present study and its analytical model, the results demonstrate that fluoride does have a preeruptive effect. It may be that an even more effective confounding system, comprising more factors and therefore requiring a larger sample of subjects, would have further reduced the crude differences.

There is no reason, however, to suppose that the differences would have been completely eliminated under such circumstances. This is important since the preeruptive effect is under debate (14,15). Our results are, moreover, corroborated by a recent analysis of studies concerning the effect of fluoridated drinking water (20).

It is of interest that the differences between the F^-- and the F^+-group decreased during the study. This indicates that the reduction of caries prevalence will continue to diminish with time, since no further difference in caries development is to be expected and both groups can be expected to get more caries. Moreover, the superimposed effects of other preventive regimes (e.g. topical application of fluorides) may mask the remaining effect of the tablets. In cross-sectional studies, BINDER (7) found a similar diminution of caries reduction with time (Table 1).

From Table 3 it can be concluded that correction for confounding was justified. The children in the F^+-group had higher counts of both *S. mutans* and lactobacilli than those in the F^--group, though the difference is not statistically significant in the period 1980-81.

It is difficult to find previous investigations that are suitable for comparisons of the preeruptive caries-reducing effect of fluoride tablet intake from early infancy (Table 1). Thus, most of the programs were either discontinued when the children were at still an early age and few permanent teeth had erupted, or continued to a higher age, with a concomitant topical effect of the tablets. However, the study of ANDERSSON & GRAHNÉN (9) did have a tablet regimen similar to ours and the reduction of proximal DF surfaces reached 53 % at the age of 8-10. On the whole, the caries reduction figures reported in earlier studies of fluoride tablet administration from an early age are considerably higher than in the present study. Apart from other discrepancies, this probably reflects the failure to take the confounding effects of various factors into account. Nevertheless, a preeruptive effect seems to exist.

REFERENCES

1. DRISCOLL WS. The use of fluoride tablets for the prevention of dental caries. In: FORRESTER DJ, SCHULZ EM, eds. International workshop on fluorides and dental caries reductions. Baltimore: University of Maryland, 1974; 25-93.
2. BINDER K, DRISCOLL WS, SCHÜTZMANNSKY G. Caries-preventive fluoride tablet programs. Caries Res 1978; 12: Suppl 1: 22-30.
3. MURRAY JJ, RUGG-GUNN AJ. Fluorides in caries prevention. 2nd ed. Bristol: Wright, 1982; 85-99.
4. HAMBERG L. Controlled trial of fluoride in vitamin drops for prevention of caries in children. Lancet 1971; 1: 441-2.
5. SCHÜTZMANNSKY G. Fluorine tablet application in pregnant females. Dtsch Stomatol 1971; 21: 122-9.
6. AASENDEN R, PEEBLES TC. Effects of fluoride supplementation from birth on human deciduous and permanent teeth. Arch Oral Biol 1974; 19: 321-6.
7. BINDER K. In: DAVIES GN. Cost and benefit of fluoride in the prevention of dental caries. WHO Offset Publication No. 9. Geneva: WHO, 1974; 21-65.
8. MARGOLIS FJ, REAMES HR, FRESHMAN E, MACAULEY JC, MEHAFFEY H. Fluoride - ten year prospective study of deciduous and permanent dentition. Am J Dis Child 1975; 129: 794-800.
9. ANDERSSON R, GRAHNEN H. Fluoride tablets in pre-school age - effect on primary and permanent teeth. Sven Tandlaek Tidskr 1976; 69: 137-43.
10. THYLSTRUP A, FEJERSKOV O, BRUUN C, KANN J. Enamel changes and dental caries in 7-year-old children given fluoride tablets from shortly after birth. Caries Res 1979; 13: 265-76.
11. HOLM A-K, ANDERSSON R. Enamel mineralization disturbances in 12-year-old children with early exposure to fluorides. Community - Dent Oral Epidemiol 1982; 10: 335-9.
12. WEATHERELL JA, ROBINSON C, HALLSWORTH AS. The concept of enamel resistance - a critical review. In: Cariology Today. Int. Congr., Zürich, 1983. Basel: Karger, 1984; 223-30.
13. BROWN WE, GREGORY TM, CHOW LC. Effects of fluoride on enamel solubility and cariostasis. Caries Res 1978; 12: Suppl 1: 118-41.

14. FEJERSKOV O, THYLSTRUP A, LARSEN MJ. Rational use of fluorides in caries prevention. A concept based on possible cariostatic mechanisms. Acta Odontol Scand 1981; 39: 241-9.
15. FEJERSKOV O. Fluoride and enamel. Summary of session and panel discussion. In: Cariology Today. Int. congr., Zürich, 1983. Basel: Karger, 1984; 362-74.
16. WIDENHEIM J, LINDGREN G, GRANATH L, BIRKHED D. Model for the study of the preeruptive effect of NaF tablets on caries in permanent teeth. Community Dent Oral Epidemiol 1985; 13: 86-92.
17. WIDENHEIM J. A time-related study of intake pattern of fluoride tablets among Swedish preschoolchildren and parental attitudes. Community Dent Oral Epidemiol. 1982; 10: 296-300.
18. SOCIALSTYRELSEN. Socialstyrelsens kungörelse om användning av fluorider i kariesprofylaktiskt syfte. SOSFS(M) 1977:26.
19. KLOCK B, KRASSE B. Microbial and salivary conditions in 9- to 12-year-old children. Scand J Dent Res 1977; 85: 56-63.
20. GRANATH L, ROOTZÉN H, GRODNICKA I, LEJERSTEDT A-C. Comparative evaluation of epidemiological caries data: water fluoridation. In manuscript.

Table 1. Caries-preventive effects on permanent teeth after administration of NaF tablets or drops from the first year of life.
S = statistically significant; NS = statistically non-significant.

Study	No. of subjects in F group	Daily dosage (mg)	Initial age of subjects (yr)	Duration of F intake (yr)	Age at examination (yr)	Caries reduction in %	Statistical significance	Comments
Hamberg (4)	342	0.5	birth	7-8	7-8	70-80	not reported	DMF 1st molars
Schützmannsky (5)	100	0.25-1.0	"	9	9	39	S	"
Aasenden & Peebles (6)	100	0.5-1.0	"	7-12	7-12	80	S	DMFT
Binder (7)	7133	0.25-1.0	"	6	6	70	S	"
	6198	"	"	10	10	55	S	"
	3084	"	"	14	14	43	S	"
Margolis *et al.* (8)	56	0.5-1.0	"	10	10	58		"
Andersson & Grahnén (9)	125	0.25-0.5	½	4-5	8-10	53	S	DF proximal surfaces
Thylstrup *et al.* (10)	23	"	0-1	> 3	7	40	NS	estimated from article
Holm & Andersson (11)	72	"	½-1	≧ 1	12	not reported	NS	DF smooth surfaces

Table 2. Differences in caries between fluoride tablet consumers (F^+), minimum 5 yr from ½ to 6 yr of age, and non-consumers (F^-) from 12 to 14 yr of age; $\bar{x}$ = means of DF proximal surfaces (from mesial surface of permanent second molars to distal surface of first premolars); $d_{\bar{x}}$ and $SE_{d_{\bar{x}}}$ = differences of crude values and standard errors of of differences; d_w and SE_{d_w} = weighted mean differences after correction for *S. mutans* and lactobacilli and standard errors of weighted mean differences; 1981 values = sum of prevalences in 1979 and incidences during 1979-80 and 1980-81; n in F^--group = 69, n in F^+-group = 49; figures in italics denote values after exclusion of first molars; p = level of significance in one-tailed tests.

	F^-	F^+	$d_{\bar{x}}$	$SE_{d_{\bar{x}}}$	d_w	SE_{d_w}	Reduction in % crude	corrected
1979	2.36	1.22 = 1.14		0.39	0.82	0.41	48.3	34.7
(12 yr)	*0.51*	*0.14 = 0.37*		*0.19*	*0.25*	*0.21*	*72.5*	*49.0*
1979-80	1.25	0.88 = 0.37		0.43	0.20	0.44	29.6	16.0
(12-13 yr)	*0.86*	*0.49 = 0.37*		*0.32*	*0.25*	*0.34*	*43.0*	*29.1*
1980-81	0.87	0.84 = 0.03		0.30	0.04	0.27	3.4	4.6
(13-14 yr)	*0.58*	*0.61 = -0.03*		*0.23*	*-0.03*	*0.22*	-5.2	-5.2
1981	4.48	2.94 = 1.54		0.65	1.06	0.66	34.4	23.7
(14 yr)		p = 0.01			p >0.05			
	1.95	*1.24 = 0.71*		*0.44*	*0.47*	*0.46*	*36.4*	*24.1*
		p = 0.05			*p >0.05*			

Table 3. Mean values ($\bar{x}$) and standard errors (SE) of microbial factors (log numbers of counts/ml saliva) in fluoride tablet consumers (F^+, n = 49) and non-consumers (F^-, n = 69); M = *S. mutans*; L = lactobacilli; p = level of significance in two-tailed tests; NS = statistically non-significant.

		M		L	
		F^-	F^+	F^-	F^+
1979 (12 yr)	$\bar{x}$	5.33	5.04	4.26	3.94
	SE	0.08	0.09	0.10	0.08
	p	<0.02		<0.02	
1979-80 (12-13 yr)	$\bar{x}$	5.47	5.25	4.15	3.91
	SE	0.08	0.07	0.06	0.06
	p	<0.05		<0.01	
1980-81 (13-14 yr)	$\bar{x}$	5.67	5.44	4.11	4.03
	SE	0.09	0.09	0.07	0.08
	p	NS		NS	

Paper 4

Diagnosis of mild enamel fluorosis in permanent maxillary incisors using two scoring systems

Lars Granath[1], Jan Widenheim[2,3] and Dowen Birkhed[2]

Departments of Pedodontics[1] and Cariology[2], University of Lund, School of Dentistry, Malmö, and Department of Preventive Dentistry[3], Malmöhus County Council, Lund, Sweden

Running title: Diagnosis of enamel fluorosis

Lars Granath, School of Dentistry, S-214 21 Malmö, Sweden.

Granath L, Widenheim J, Birkhed D: Diagnosis of mild enamel fluorosis in permanent maxillary incisors using two scoring systems. Community Dent Oral Epidemiol 1985; 13:000.

Abstract - The main purpose of this study was to compare the diagnosis of mild enamel fluorosis as established by two scoring systems, that of Dean based primarily on quantitative aspects and that of Thylstryp & Fejerskov with a preferentially qualitative approach. A further aim was to study the prevalence of fluorosis in permanent maxillary incisors after intake of fluoride tablets for minimum 5 yr between ½ and 6 yr of age in accordance with recommendations from the National Swedish Board of Health and Welfare. Maxillary incisors were examined in 118 13-year-old children; 49 constituted a tablet group and the remaining 69 a control group who had never consumed tablets. Scored according to Dean, the difference in enamel fluorosis between the two groups was statistically not significant at the 5 % level, whereas the system of Thylstrup & Fejerskov did give a significant difference. The frequency of fluorosis was substantially lower than that resulting from consumption of drinking water in Uppsala, Sweden, containing 1-1.2 ppm F. A probable relationship was found between the scoring systems, particularly if Dean score 0.5 ("questionable") was converted to score 1. To ensure correct diagnosis, one should expose the tooth surface to prolonged drying and apply relevant criteria for the differential diagnosis of disturbances of other origin. The higher sensitivity of Thylstrup & Fejerskov's system relates to score 1, narrow white lines located corresponding to perikymata. Here there seems to be a risk of over- or under-diagnosing. Recommendations are given for epidemiologic surveys and for experimental trials of limited size.

Key words: Enamel fluorosis, fluoride tablets.
Lars Granath, School of Dentistry, S-214 21 Malmö, Sweden.

It is agreed nowadays that children who receive fluoride supplementation in the form of tablets from early infancy run a certain risk of developing enamel fluorosis in their permanent teeth. Thus, AASENDEN & PEEBLES (1) reported fluorosis in 84, HOLM & ANDERSSON (2) in 45, and POWELL *et al.* (3) in 33 %. The respective control values were 17, 15, and 16 %. The particular observation that fluorosis decreases with age was made by AASENDEN & PEEBLES (4), who ascribed the phenomenon to a gradual mineralization of affected areas. There is clear evidence, however, that the occurrence and severity of fluorosis are dose dependent and related to age at initial administration. HOLM & ANDERSSON (2), for instance, found that children who had consumed tablets for at least 12 months from the age of 6 months ran a 5.4 times greater risk than children with no such intake, while the corresponding figure for children who had started their consumption at the age of 24 months was only 2.5.

When the present study was performed in 1980, one Swedish investigation (5) applying the scoring system of DEAN (6) had reported no increase of enamel fluorosis in 8 - 10-yr-old children after intake of fluoride tablets during the first five years of life. On the other hand, a Danish study (7), using a new, more sensitive scale according to THYLSTRUP & FEJERSKOV (8) for the assessment of fluorosis, but otherwise with similar prerequisites for tablet dosage and period of intake, found an increased frequency in 7-yr-old children. This was corroborated by HOLM & ANDERSSON (2) using the new scale in 12-yr-olds. The study of WENZEL & THYLSTRUP (9) is the only one, where results obtained with the two systems in one and the same material have been compared. These authors analysed their data in order to establish a level of agreement with regard to increasing severity.

We have studied and are currently studying, a fluoride tablet group and a control group of children with respect to parental attitudes to intake of tablets (10) and to the endogenous cariostatic effect on permanent teeth (11). It seemed of interest to use the same material to estimate of the occurrence and severity of enamel fluorosis, with particular emphasis on comparing results for the two above-mentioned scales in order to elaborate a model for convertion of data.

MATERIAL AND METHODS

The material comprised 118 13-yr-old children. Forty-nine of them had consumed sodium fluoride (NaF) tablets (0.25 mg F) for minimum 5 yr between ½ and 6 yr of age (tablet group) in accordance with recommendations from the Swedish National Board of Health and Welfare. The fluoride concentration of the drinking water was 0.2 ppm. The recommended dose in such an area is 1 tablet daily between ½ and 1½ yr of age, thereafter 2 tablets. Information about tablet consumption had been obtained from the parents when the children were about 8 yr of age, as described elsewhere (10). The remaining 69 children had not used NaF tablets at all (control group).

Before the examination, some basic criteria of less advanced enamel fluorosis were set for both scoring systems to differentiate localized opacities of other origin. These were as follows.

1. The hypomineralized area should have a diffuse border to normal enamel or a stepless transition to neighbouring areas of less advanced hypomineralization (8).
2. When fluorosis appears in homologous teeth, as it does in the great majority of cases, it should show a non-identical pattern in the two teeth.

Otherwise, the criteria of the two scales, excluding advanced stages with loss of outermost enamel, are given in Table 1. Mineralization disturbances that did not meet the criteria for fluorosis were not recorded.

The buccal surfaces of maxillary incisors were examined. Three teeth were missing and another four teeth had been restored with composite fillings after traumatic injuries and were therefore excluded from the study. The examination was performed in a dental chair with optimal lighting. First, the teeth were dried with cotton-wool rolls and compressed air for a few seconds, whereafter each incisor of a subject was diagnosed for enamel fluorosis according to DEAN (6). Then the teeth were exposed to a prolonged air blast and the diagnostic procedure was repeated, this time according to THYLSTRUP & FEJERSKOV (8). We performed the examinations simultaneously, though in

a few cases only two of us were present. All scoring was carried out without knowing whether the child belonged to the tablet or the control group. Finally, the children were grouped with respect to the tooth with the most advanced degree of fluorosis.

The statistical analysis was performed as X^2 tests. Differences at the 5 % level of probability are considered to be statistically significant.

RESULTS

Enamel fluorosis scored according to DEAN (6) was found in 14 tablet-group children (29 %) and in 10 controls (15 %). The difference is statistically not significant ($X^2 = 3.51$, d.f. = 1). The corresponding figures scored according to THYLSTRUP & FEJERSKOV (8) were 17 (35 %) and 11 (16 %). This difference is statistically significant ($X^2 = 5.57$, d.f. = 1). The distribution of the children with respect to degree of fluorosis is shown in Table 2. The fluorosis was bilateral in all cases but two.

Four hundred and sixty-five teeth were studied, 193 in the tablet group and 272 in the control group. No tooth was scored higher than 2 according to DEAN (6) and 3 according to THYLSTRUP & FEJERSKOV (8). The distribution of the teeth by degree of severity, cross-tabulated with respect to the two scales, is shown for the tablet group in Table 3 and for the control group in Table 4. The general pattern of the two groups is the same. In the tablet group, 3 teeth with the combination T & F 1/Dean 0.5 were moved to combination T & F 1/Dean 0. Eight teeth in the control group were treated in the same way. This was done because the combination in question is not logical in relation to the criteria; see the third paragraph under *Discussion*.

DISCUSSION

In the present study, compared with children of the same age without tablet supplementation, the prevalence of enamel fluorosis was found to be higher in 13-yr-old children who had consumed NaF tablets from the age of 6 - 12 months to 6 yr, in accordance with directions from the National Swedish Board of Health and Welfare, in an area with a

fluoride concentration of 0.2 ppm in the drinking water. This is in agreement with most earlier studies. The difference proved to be higher when the teeth were scored according to THYLSTRUP & FEJERSKOV (8) compared to DEAN (6). Irrespective of the scoring system, there was a shift at all levels towards higher scores in the tablet group compared to the control group. The mottling was mild, however, and could in no case be regarded as cosmetically disturbing.

In a recent investigation undertaken by the National Swedish Board of Health and Welfare (12), in which one of us (LG) belonged to the group of examiners, the frequency of enamel fluorosis was studied among 564 13-yr-old children who had lived since birth in Uppsala (1-1.2 ppm F in drinking water). The subjects who were scored 0, 0.5, 1, 2, or 3 according to DEAN (6) constituted 32.5, 31.0, 24.0, 8.0, and 4.4 %, respectively. This shows that after recommended administration of fluoride tablets from early infancy, the prevalence and severity of fluorosis are low compared with values after consumption of drinking water with a fluoride content that is considered to be optimal for cariostasis. The occurrence of fluorosis in Uppsala was about the same as a decade earlier (13). This is important, since the utilization of various kinds of topical administration of fluoride has increased in the intervening period. The results for Uppsala agree with those from other studies. HOUWINK & WAGG (14) did not find that fluoride toothpaste gave increased fluorosis, a result that was corroborated by HOLM & ANDERSSON (2).

The transfer of teeth from the combination T & F 1/Dean 0.5 to T & F 1/Dean 0 calls for an explanation. First, it is not logical to combine T & F 1 with Dean 0.5. Since a diagnosis according to THYLSTRUP & FEJERSKOV (8) requires prolonged air-drying of the surface, the appearance of occasionally confluent white perikymata lines is likely to be registered more correctly than according to DEAN (6). If all moisture is not removed from the surface, refraction phenomena can cause neighbouring white lines to simulate white flecks of limited extension. Second, true such flecks are scored 2 according to THYLSTRUP & FEJERSKOV (8). Tables 3 and 4 show that this manipulation leads to a logical pattern of increased frequency of enamel fluorosis in the tablet group for all combinations of fluorosis scores.

The above raises some interesting aspects in a comparison of the two scales' validities. Table 5 presents an attempt to correlate them. We generally prefer the biological approach of THYLSTRUP & FEJERSKOV (8), which is based on increasing hypomineralization with simultaneously increasing depth from the tooth surface to the amelo-dentinal junction. The scale according to DEAN (6) reflects the quantitative rather than the qualitative aspects of fluorosis. As the table shows, in DEAN's (6) scale there is no reason to include score 0.5. HOROWITZ *et al.* (15) presented recently a new Tooth Surface Index of Fluorosis without any "questionable" category. Further, in a survey of the literature, MYERS (16) found that this category tends to increase percentagewise with an increasing level of fluoride in drinking water (from 0 to 1.3 ppm), which is in accordance with the present non-threshold concept of fluorosis versus water F content (8). When white flecks of limited extension are diagnosed according to certain basic criteria (17), they do belong to score 1. This simplification of the scale does not, however, overcome the problem of narrow white lines corresponding to the perikymata.

In the present study, the frequency of controls with fluorosis was about 15 %, which is the same as reported by HOLM & ANDERSSON (2). In their tablet group, however, 81 % had fluorosis, compared with 30-35 % in our study. Re-calculation of data from THYLSTRUP *et al.* (7) gives an approximate figure of 40 %, but only about half of the children in that investigation had received fluoride tablets during the first year of life. According to Dr Anna-Karin Holm (personal communication), a majority of the tablet children with fluorosis in their study (2) were scored 1. That the same applied in the study of THYLSTRUP *et al.* (7) is apparent from their data. This might be interpreted as an appreciable risk of under- or over-diagnosing the very first signs of narrow white lines.

We therefore recommend that in epidemiologic surveys, possible narrow white lines corresponding to perikymata should be scored zero. If score 0.5 ("questionable") is converted into score 1, as said earlier, resulting in a slight modification (simplification) of the classification according to DEAN (6), either scale can be used, and comparisons are reasonably facilitated. When the borderline between no fluorosis and fluorosis was set between scores 1 and 2 acoording to

THYLSTRUP & FEJERSKOV (8), the X^2 quantity was only slightly changed, from 5.57 to 6.65 in the test of the difference between the tablet and the control group. WENZEL & THYLSTRUP (9) concluded that the classification according to DEAN (6) is capable of outlining the severity of enamel fluorosis in larger populations resident in areas with less than 3 ppm F in drinking water. If more detailed information is required in experimental trials of limited size, we would recommend the system of THYLSTRUP & FEJERSKOV (8).

REFERENCES

1. AASENDEN R, PEEBLES TC. Effects of fluoride supplementation from birth on human deciduous and permanent teeth. Arch Oral Biol 1974; 19: 321-6.
2. HOLM A-K, ANDERSSON R. Enamel mineralization disturbances in 12-year-old children with known early exposure to fluorides. Community Dent Oral Epidemiol 1982; 10: 335-9.
3. POWELL JA, NOBERT LD, HARGREAVES JA. Fluorosis and dental caries in children receiving fluoride supplementation. J Dent Res 1983; 62: Spec Issue. AADR Abstr No 304.
4. AASENDEN R, PEEBLES TC. Effects of fluoride supplementation from birth on dental caries and fluorosis in teenaged children. Arch Oral Biol 1978; 23: 111-5.
5. ANDERSSON R, GRAHNEN H. Fluoride tablets in pre-school age - effect on primary and permanent teeth. Swed Dent J 1976; 69: 137-43.
6. DEAN HT. The investigation of physiological effects by the epidemiological method. In: MOULTON FR, ed. Fluorine and dental health. American Association for the Advancement of Science: Washington. DC, 1942; 23-31.
7. THYLSTRUP A, FEJERSKOV O, BRUUN C, KANN J. Enamel changes and dental caries in 7-year-old children given fluoride tablets from shortly after birth. Caries Res 1979; 13: 265-76.
8. THYLSTRUP A, FEJERSKOV O. Clinical appearance of dental fluorosis in permanent teeth in relation to histologic changes. Community Dent Oral Epidemiol 1978; 6: 315-28.
9. WENZEL A, THYLSTRUP A. Dental fluorosis and localized enamel opacities in fluoride and nonfluoride Danish communities. Caries Res 1982; 16: 340-8.
10. WIDENHEIM J. A time-related study of intake pattern of fluoride tablets among Swedish preschoolchildren and parental attitudes. Community Dent Oral Epidemiol 1982; 10: 296-300.
11. WIDENHEIM J, LINDGREN G, GRANATH L, BIRKHED D. Model for the study of the preeruptive effect of NaF tablets on caries in permanent teeth. Community Dent Oral Epidemiol 1985; 13: 000-000.

12. SOU (Statens offentliga utredningar) 1981:32. Fluor i karies-förebyggande syfte. Betänkande av fluorberedningen. Socialdepartementet, Stockholm.
13. RIBELIUS U, TORELL P. Förekomst av emaljfluoros i Uppsala. Tandläkartidningen 1974; 66: 358-62.
14. HOUWINK B, WAGG BJ. Effect of fluoride dentifrice usage during infancy upon enamel mottling of the permanent teeth. Caries Res 1979; 13: 231-7.
15. HOROWITZ HS, DRISCOLL WS, MEYERS RJ, HEIFETZ SB, KINGMAN A. A new method for assessing the prevalence of dental fluorosis - the tooth surface index of fluorosis. J Am Dent Assoc 1984; 109: 37-41.
16. MYERS HM. Dose-response relationship between water fluoride levels and the category of questionable dental fluorosis. Community Dent Oral Epidemiol 1983; 11: 107-12.
17. NEVITT GA, FRANKEL JM, WITTER DM. Occurrence of non-fluoride opacities and non-fluoride hypoplasias of enamel of 588 children aged 9-14 years. J Am Dent Assoc 1963; 66: 65-9.

Table 1. Criteria for diagnosis of mild levels of enamel fluorosis according to DEAN (6) and THYLSTRUP & FEJERSKOV (8).

Dean Score	Criteria	T & F Score	Criteria
0	*Normal*: The enamel presents the usual translucent semivitriform type of structure. The surface is smooth glossy, and usually of a pale creamy white color.	0	Normal translucency of enamel remains after prolonged air-drying.
0.5	*Questionable*: The enamel discloses slight aberrations from the translucency of normal enamel, ranging from a few flecks to occasional white spots.	1	Narrow white lines located corresponding to the perikymata.
1	*Very mild*: Small, opaque, paper white areas scattered irregularly over the tooth but not involving as much as approximately 25 per cent of the tooth surface.	2	More pronounced lines of opacity which follow the perikymata. Occasionally confluence of adjacent lines.
2	*Mild*: The white opaque areas in the enamel of the teeth are more extensive but do not involve as much as 50 per cent of the tooth.	3	Merging and irregular cloudy areas of opacity. Accentuated drawing of perikymata often visible between opacities.

Table 2. Percentage distribution of 118 13-yr-old children with respect to each child's maxillary incisor with the most pronounced enamel fluorosis, classified according to DEAN (6) and THYLSTRUP & FEJERSKOV (8); 49 children had consumed NaF tablets (0.25 mg F) for minimum 5 yr between ½ and 6 yr of age, with 1 tablet per day between ½ and 1 ½ yr, thereafter two tablets; 69 children had never consumed tablets; 0.2 ppm F in drinking water; number of children within brackets.

	Dean				T & F			
	0	0.5	1	2	0	1	2	3
Tablet group (49)	71.4 (35)	4.1 (2)	14.3 (7)	10.2 (5)	65.3 (32)	6.1 (3)	8.2 (4)	20.4 (10)
Control group (69)	85.5 (59)	5.8 (4)	5.8 (4)	2.9 (2)	84.1 (58)	5.8 (4)	1.4 (1)	8.7 (6)

Table 3. Percentage distribution of enamel fluorosis in 193 maxillary incisors in 49 13-yr-old children who had consumed NaF tablets (0.25 mg F) for minimum 5 yr between ½ and 6 yr of age, classified according to DEAN (6) and THYLSTRUP & FEJERSKOV (8); 1 tablet per day between ½ and 1½ yr, thereafter 2 tablets; 0.2 ppm F in drinking water.

T & F \ Dean	0	0.5	1	2
0	69.9			
1	6.2	*		
2		6.7	4.1	
3			7.3	5.7

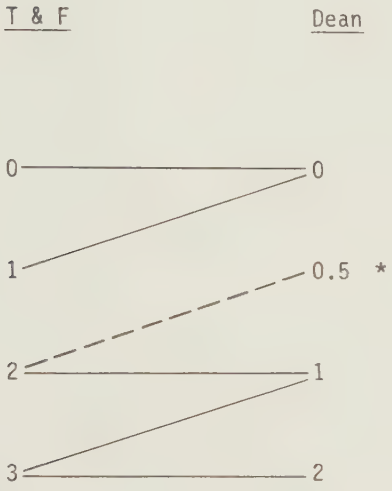
* 3 teeth with this combination transferred to T & F 1/Dean 0; for explanation, see text.

Table 4. Percentage distribution of enamel fluorosis in 272 maxillary incisors in 69 13-yr-old children who had never consumed NaF tablets, classified according to DEAN (6) and THYLSTRUP & FEJERSKOV (8); 0.2 ppm F in drinking water.

T & F \ Dean	0	0.5	1	2
0	87.9			
1	3.3	*		
2		3.7	0.4	
3			3.7	1.1

* 8 teeth in this combination transferred to T & F 1/Dean 0; for explanation, see text.

Table 5. Probable relationship between mild scores of enamel fluorosis classified according to THYLSTRUP & FEJERSKOV (8) and DEAN (6).



* should be classified as score 1 provided the enamel alterations are correctly diagnosed as fluorosis according to NEVITT *et al* (16).